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Looking ahead

THIS month's cover photograph, showing a willing 'victim' of medical electronics, illustrates the recording of eye movements. A television camera is trained on the reflection of a spot of light from the front surface of the eye. Dr. E. Llewellyn-Thomas and Dr. N. H. Mackworth describe the 'television eye marker' and its applications in an article starting on p. 331. Eye movements are, in fact, of direct interest not only to the medical profession but also in the field of human engineering, particularly the man-machine relationship.

The electronic aspects of sight, hearing and locomotion are to be discussed at the forthcoming International Conference on Medical Electronics, an introduction to which is given in this month's Foreword (see also p. 355)

Secretary W. K. BRASHER, C.B.E., M.A., M.I.E.E. *Editor* W. G. ASKEW, M.C.

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JOURNAL

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SAVOY PLACE LONDON W.C.2 VOLUME 6 NUMBER 66 JUNE 1960

HEALING BECOMES ELECTRA

From the 21st to 27th July 1960, at the Empire Hall, Olympia, London, an event is taking place which is likely to prove of some significance in the history of The Institution. This is the Third International Conference on Medical Electronics with its scientific exhibition, organized by the Electronics and Communications Section of The Institution in association with the International Federation for Medical Electronics.

Its importance stems from the way in which our profession, and particularly its electronics aspect, is becoming indispensable to every technological field—a development arising from a creative energy and which necessitates the broadest possible outlook if our Institution is properly to discharge its duty to the community.

Medicine, with its grave responsibilities for life, health and happiness, is among the most conservative of the professions, and it is only in recent years that the enormous range of electronic techniques of measurement and the production of radiated power of all types have begun to be applied to medical diagnosis and therapy.

For those unfamiliar with medical electronics it may be helpful to mention a few examples in modern medicine. The pressure and the flow rate of blood in the veins and arteries which feed energy to the various parts of the body can be measured by inserting small transducers which convert pressure and flow into electrical signals. A radio transmitter may be made sufficiently small to be swallowed by the patient and to signal from the digestive tract measurements of acidity and pressure.

It is possible to insert in the heart by surgical methods miniature electronic pulse generators which will control its beat. The heart may be taken out of circulation for repairs while its duties are taken over by an artificial organ under electronic control. Aids for the deaf, the blind, and the crippled are being made more effective by electronic means. Finally, the routine measurements such as of temperature and pulse may by electronic means be made instantaneous and be automatically recorded, and it has been calculated that this alone would provide a great saving in 'nurse-days' in our hospitals.

The Institution has recognized the link between electrical engineering and medicine from the earliest days of radiology, and many lectures have been given in the Institution building by members of the medical profession. In 1958 a meeting of medicals and electricals, held under the auspices of The Institution, inaugurated what has become the United Kingdom Discussion Group on Medical Electronics, which has since held regular meetings on a wide range of subjects.

In February 1959 the then Radio and Telecommunication Section appointed a Panel on Medical Electronics to stimulate papers in this field, and one of its first proposals was to hold an international conference with an associated scientific exhibition in 1960 in order to bring the research, design and manufacturing potential of the electronics profession and industry into contact with the medical profession and closely associate the two disciplines on an international scale.

In parallel with these developments, Dr. V. K. Zworykin, devoting his knowledge and experience to the sphere of medical electronics after his well known pioneering work in television, initiated a small international meeting in Paris in June 1958 to present outline papers and to consider ways in which medicine and electronic engineering could be brought into closer partnership. Nine British representatives attended as observers after discussions arranged by The Institution's Joint Panel on Radiological and Electromedical Apparatus. At a further meeting in Paris in 1959, the International Federation for Medical Electronics was formed.

The first meeting of the Federation welcomed the initiative of The Institution in planning its conference in 1960, and it was mutually agreed to make it the Third International Conference and to delegate its organization

to our Electronics and Communications Section. Thus the conference has crossed the Channel from Paris to London, and the opportunity has been provided for the British professional bodies and British industry to act as hosts to the rest of the world.

The conference is being planned on the basis of an attendance comparable with that of the 1959 Transistor Convention, with the thought that many electronics engineers and medical men not at present active in the field of medical electronics may wish to learn of its potentialities and to contribute to its future development, while it will at the same time provide what is in effect a specialist meeting within the conference for those already working in the sphere.

This has led naturally to the arrangement of general sessions, which will consist mainly of lectures by internationally known experts, presented in such a way that they can be followed by both medicals and electronics engineers, and of specialist sessions, which will be based primarily on submitted papers. There is evidence of a comprehensive programme of work originating in many different countries.

The first floor of the Empire Hall at Olympia is being planned as a conference area with a conference hall at each end and between them a delegates' lounge. The ground floor will house the exhibition, and this will be open by invitation to any with an interest in this new technology. This combination of conference area and exhibition area should provide a good environment, and there will be adequate restaurant and buffet facilities.

The Organizing Committee have had it in mind that many hospitals and research bodies may not have the financial facilities for taking a stand at the exhibition, and for these is being provided a special research area containing suitable tables on which their work may be displayed without charge.

Finally, in order to make this conference and exhibition widely known internationally, some 100 000 copies of a preliminary leaflet have been printed in five languages and distributed not only through engineering and medical professional channels but also through the co-operation of some 40 individuals abroad who are acting as National Co-ordinators for the Organizing Committee.

The official languages for the conference are English, French and German, although in view of the expected preponderance of English-speaking delegates it is hoped that all those able to do so will present their work in English. Simultaneous-translation facilities will be provided should the need be seen to be justified. A brief outline of the programme is given on p. 355.

To sum up, this conference and exhibition furnish an example of the way in which our profession is meeting the needs of the ever-expanding field of electronics, and will, we are confident, receive the fullest possible support of members.

Electrical risks in the home

DEEP concern is felt by the Committee on Consumer Protection about the sale in the United Kingdom of imported electrical appliances whose connecting wires are not coloured according to the British code (see January 1960 *Journal*, p. 8). The committee believe there is an urgent need for prohibiting the sale of equipment which carries a risk of such confusion.

The committee was set up in the summer of 1959 to review the working of existing legislation and to consider whether any other measures were desirable for the further protection of the public, and their interim report has recently been published.*

Analysis of fatal accidents in the home involving electrical appliances and fittings showed that the commonest causes were carelessness, misuse, and 'inexpert tinkering', and better education in matters of safety is recommended. The committee disagree with the suggestion put to them that cable and fittings should be made less readily available to the amateur handyman wishing to repair his household installation.

The dangers of electric blankets were examined. The chief hazard, fire, developed either through the blanket being rucked, or through undue flexure resulting in fracture of the thin wires of the heating-element. The committee are not satisfied that operation at low voltage through a transformer affords sufficient protection; and a thermostatic control to provide an effective safeguard would not be practicable at a price the customer would pay. There might be a case for requiring warnings to be permanently attached to each blanket.

There was imprecise evidence about the sale of small electrical appliances at low prices in which 'live' parts could be accidentally touched or in which sharp edges and unbushed holes could cut through wiring insulation. In view, however, of one known example, the committee tentatively suggest that the enforcement of minimum standards might be worth consideration.

The danger of toys is still being examined. It may prove necessary to insist that electrical toys be operated at low voltage, and if this involved a transformer its safety and durability might require regulation.

The committee emphasize that electrocutions account for less than 1% of accidental deaths in the home, and that they are generally satisfied with the concern of the manufacturing industry for the safety of their products. The committee's aim was 'to ensure that what has been achieved . . . by the responsible majority should not be sapped by the occasional dereliction of a small minority, or by an irresponsible importer'.

* Cmd. 1011, H.M.S.O., London. 1s.

Recording of eye movements by the television eye marker

621.397.9:612.846

In many situations it is important to know where a man is looking as he studies a fixed or moving scene before him. This article describes a method of simultaneous display, on a television monitor, of the scene and the positions of gaze, and also shows how eye movements, demonstrated in this way, can be recorded or used as control mechanisms. The article contains the first publication in outline of the optical mixing system employed.

The authors are at the Defence Research Medical Laboratories, Toronto, Ontario, Canada.

In this connection, it is of interest to recall that the Third International Conference on Medical Electronics is being held in London on the 21st–27th July 1960 (see p. 329).

E. LLEWELLYN-THOMAS, M.D., C.M., B.SC., P.ENG., ASSOCIATE MEMBER, and

N. H. MACKWORTH, M.B., B.S., PH.D.

THE study of the movement of the human eye, and where a man actually looks when he is surveying a fixed or moving scene, is of importance in three main areas of science. First, it is a valuable method in basic psychological and physiological research, and particularly the psychology and physiology of vision. Secondly, it can be used in medicine as one of the methods of investigation of various pathological conditions, and has particular application to ophthalmology, to neurology, and to psychiatry.

The third area in which the study of eye movement is of interest is the investigation of the human being as an operator, and especially the man–machine relationship, the field of human engineering. Typical examples of this are the rapidly changing visual worlds of the pilot of a high-speed aircraft, of the engineer on a main control panel, of the inspector on a production line, of the radar operator, of the ordinary automobile driver and of the astronaut.

Whereas in the past the design engineer has been able to depend on the human operator to take up a certain amount of the 'backlash', or to offset errors in design, as the speed of decision-making increases the presentation of the data to the operator in the most easily perceived form is becoming one of the most important factors in the human element of the control chain. It is this aspect, therefore, of the study of eye movements which is perhaps of the greatest interest to electrical engineers.

Methods of studying eye movements

There are various ways in which movements of the human eye can be studied, and those in general use at present can be classified in three main groups. First, still or moving pictures of the eyes themselves can be taken. The second group includes methods utilizing either the voltages generated by the muscles rotating the eyeball, or the standing potential difference between the front and back of the eyeball. The third group involves the reflection of a light from the front surface of the eye.

All three types of method have their advantages and disadvantages. This article discusses techniques for utilizing the reflection from the front surface of the eye, which have been developed by Mackworth and Mackworth at the Medical Research Council's Applied Psychology Research Unit in Cambridge, England, and by Mackworth and Llewellyn-Thomas at the Defence Research Medical Laboratories in Toronto, Canada.

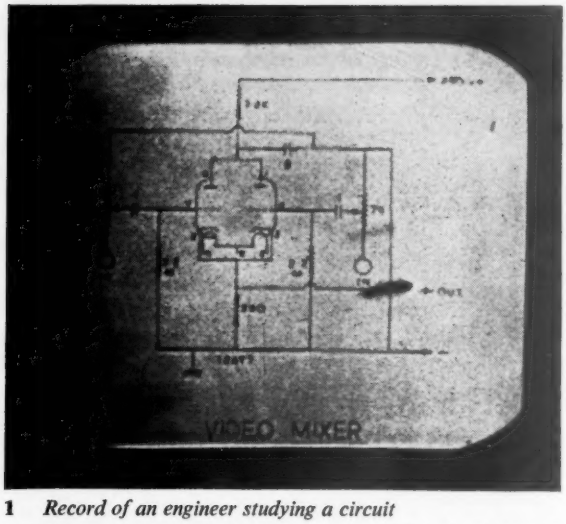
The reflection from the front surface of the eye is called the corneal reflection and can readily be seen in the eye of another person, when the eye is illuminated by a light. Because the cornea is a segment of a sphere superimposed on the eyeball, which is another sphere of larger radius, movement of the eyeball results in movement of the corneal reflection, and within about 15° on either side of the mid-line there is a direct correlation between the position of the corneal reflection and the direction of gaze.

The method described by Mackworth and Mackworth is called the television eye marker. In this the corneal reflection is viewed by one television camera, while a second television camera surveys the subject's field and the two camera outputs are mixed electronically. The result is a composite television picture which shows the scene with a bright spot of light superimposed upon it. This spot of light is called the eye marker and indicates the position of the gaze from instant to instant.

Televising the corneal reflection

The corneal reflection is picked up by a television camera with its lens close to the eye. The head must be held quite still, as movement artefacts are easily introduced; a head movement as small as 0·075mm is detectable as an apparent movement of the corneal reflection. The television camera is mounted at 45° to the line of regard, on the right, with the lens at eye level and approximately 2in. from the eye. At an angle of 45° to the left, also at eye level, is the light source, a concentrated 10watt arc lamp, provided with a permanent metallic anode and a zirconium oxide cathode sealed in an argon-filled glass bulb.

The light is passed through a filter to remove the ultra-violet component and then focused by a lens of +9 dioptres so that an image is produced at the surface of the cornea. The image is very small, and although it falls directly on the eye it is surprising how little it interferes with vision, presumably because only a small part of the light enters the eye, the rest being reflected from its surface.



1 *Record of an engineer studying a circuit*

The motion picture shows that he traces the circuit through logically, quite unlike the pattern with an untrained person. The photograph is a 'still' from the 16mm film which forms the record of the actual experiment

The corneal reflection moves about 2mm for an eye movement of about 20°. This movement must therefore be magnified so that the movement of the eye marker is equal to the movement of the fixation point in the scene. This requires a magnification of about 100, which is achieved by the optical-lens system of the eye television camera.

Televising the scene

A second television camera surveys the scene studied by the subject, and the output of this camera is mixed with that of the eye camera in an electronic mixing unit and the combined output fed to a monitor television screen. This combined eye–scene picture can then be viewed directly by the investigator and recorded by a motion-picture camera.

An example of such a record is shown in Fig. 1, which is a record taken of an engineer studying a video mixer circuit. The way in which he traces the whole circuit through is very clearly demonstrated in the film, and affords valuable insight into the way an individual attacks a problem of this nature. Records of non-technical people reading such a circuit are quite different.

The eye spot and the visual scene are co-ordinated by adjusting the position of the spot and the magnification of its movement while the subject fixes his gaze on known points within the visual scene.

Optical mixing systems

Instead of using two television cameras and mixing their outputs electronically, the picture of the scene and that of the eye reflection can be combined optically. In this system the corneal reflection is transferred through a magnifying periscope onto the left-hand face of a beam-splitting prism. This type of prism transmits 30% of the incident light and reflects 30% through 45°, while 40% is absorbed by the reflectance coating, in the same way as a half-silvered mirror set at 45°.

The scene is brought onto the front face of the prism, and the television camera looks into the prism from the rear. It thus records the scene transmitted directly through the prism, together with the corneal reflection reflected from the 45° face, and produces a composite picture consisting of the scene with the corneal reflection superimposed.

While the accuracy obtained by this method at present is not as great as when a separate television camera is employed for the corneal reflection, it has the advantage that the optical mixing equipment and the single television camera can be mounted on a firmly fitting helmet, so that the head need no longer be fixed. Not only does this allow investigations to be conducted remote from the laboratory bench but it also records head movements as well as eye movements, because the changing scene reveals the movements of the subject's head, while the movements of the eye marker within the scene indicate the movement of his eyes. Thus the entire visual response, which comprises both head and eye movements, is recorded.

A system is also in use in the Defence Research Medical Laboratories in which the head-mounted television camera is replaced by a small motion-picture camera. This records the combined eye–scene picture emerging from the beam-splitting prism and leaves the subject quite free to move, unencumbered by trailing cables.

Use of fibre optics and the television eye marker

A fibre optic allows an image to be transferred along a bent, and if necessary flexible, pathway. It comprises a number of glass fibres each of about 50μ (0·002in.) diameter regularly arranged into a bundle. The wavelengths of visible light lie in the range 0·4–0·8μ, so that light travels along each fibre by successive total internal reflections, in the same way that microwave energy travels down the more familiar waveguide. Thus an image is transferred along the bundle by breaking it up into separate components and transmitting each of these components independently from one end to the other.

A $\frac{1}{4}$in.-square bundle will contain about 15000 fibres and give a fair-quality picture. (The possibilities of such a system are described in a patent by J. L. Baird dated 1927.)

With the electronic mixing system, movement artefacts arise due to movements of the head relative to the television eye camera, and for this reason the head must be firmly fixed. A fibre optic, however, is flexible, and its use to transfer the image of the corneal reflection from the eye to the camera requires only that one end be fixed relative to the head. This is done by fixing the one end of the fibre optic to a helmet close to the eye so that the head is left relatively free to move. In this way the difficulty of fixing the head firmly is avoided although, as the scene camera is fixed, only small movements of the head are possible.

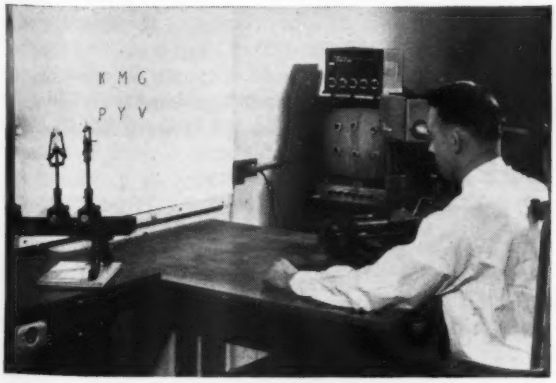
The fibre optic in use in the Defence Research Medical Laboratories provides ample resolution and light-transfer properties for a good television eye spot.

It would also be possible to transfer the mixed image from the optical mixing system described above through a flexible fibre optic to a fixed camera on the bench. This would allow full head movements and at the same time avoid the necessity of mounting a relatively heavy television or motion-picture camera on the helmet.

The fibre optic itself might also be used as a mixing system. This would involve the construction of a special unit in which one bundle would transfer an image of the scene and a second bundle the image reflected from the eye, the two bundles being interwoven at one end to superimpose the two images into a single picture. The development of such a mixing system will depend on the advance of the art of manufacturing fibre-optical systems.

Recording and evaluation

Observations may be made directly from the screen, but permanent records offer a number of advantages. Such records can be made by photographing the television monitor with a motion-picture camera, the film being examined frame by frame. This is practical for short runs but the examination becomes very tedious with records of considerable length. In addition, the data will often require computer analysis, so that a need is recognized for records in a form suitable for direct inclusion in a programmed sequence.

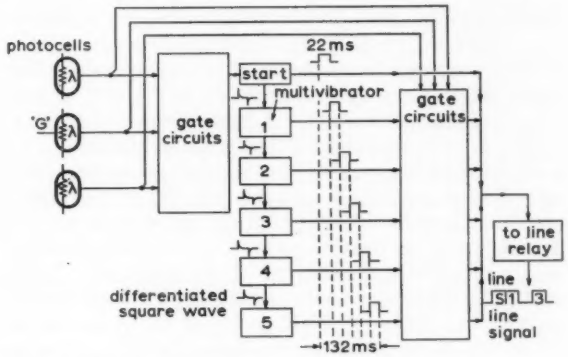


2 *The television eye marker and monitoring photocells*

As the subject looks at a letter, the television eye marker on the monitor screen moves under the corresponding photocell and the appropriate signal is printed by the teletype machine

Photocells can be used for such recording by mounting them at various positions on the monitor screen (Fig. 2) and adjusting the sensitivity of each cell so that it will be energized only when the spot of light falls directly on it. In this way a matrix of cells can be arranged with each cell corresponding to a particular position of fixation in the scene.

Each photocell is associated with a separate gating circuit which generates a distinctive signal in the teletype code. When a photocell is energized by the bright spot of light representing the corneal reflection, a signal is generated which is unique for that photocell and thus for a specific position of visual fixation. The total output



3 *Coding circuit*

When a photocell is illuminated by the eye marker, a signal in teletype code is applied to the line

therefore comprises a series of signals, in the teletype code, in which each character represents a particular position of visual fixation.

These signals are used to operate a teletype machine that produces a tape perforated in the five-perforation teletype code as well as with corresponding typed characters superimposed on the same tape.

Coding and gating circuits

While each photocell is associated with a separate gating circuit, the source of the gated signals is a common coding circuit which generates the elements of the teletype code. This circuit (shown in Fig. 3) consists of a series of one-shot multivibrators, each of which gives a square-wave output of 22 millisec duration, which is the duration of an element in the teletype code.

The first multivibrator is called the starter, and is triggered when any photocell is energized. The remaining multivibrators are connected so that the end of the differentiated square wave from the starter triggers number one multivibrator, the end of the differentiated square wave from number one triggers number two, and so on down the chain. There are thus available six

22 millisec square waves, each one following immediately after the other.

Each photocell also operates a gating circuit, which selects those square-wave pulses which are required for the coding of the symbol for that particular photocell. For example, when the photocell G is illuminated, the start pulse and pulses from multivibrators one and three will be passed through the gates, and the line relay will transmit the teletype code for G. The correct timing of the multivibrator pulses is maintained because of the 22 millisec delay while multivibrator two is generating its square wave. The output to line therefore consists of d.c. signals in the teletype code, each equivalent to one position of eye fixation.

The television eye marker as a control mechanism

In the above method the corneal reflection is used to control a teletypeset. It can obviously be used for other control purposes. It has been used to control information presented to the subject himself and in this way to form part of a feedback loop. An example of this is the investigation of visual perception during eye movements.

Eye movements are of two main types, slow pursuit movements and rapid jumps. The latter are called 'saccadic' and are the type of eye movement made in moving from one fixation point to another, as in reading; this is the most common type of eye movement. During these rapid jumps, visual appreciation is greatly reduced and, in fact, there may be no visual perception at all. There are difficulties in investigating this situation, because vision is normal while the eyes are stationary at the beginning and end of the movement, and the problem is to decide whether an object was seen during a movement, or at the beginning or end of the movement.

This difficulty can be overcome by using the corneal reflection to control the stimulus, so that a symbol is illuminated only when the eye starts to move, and is darkened as soon as the eye has swept over it. This illumination is controlled by two photocells on the monitor television screen, one placed at a point corresponding to the start of the eye movement and the second at a point just beyond the symbol along the swept pathway.

Various time-delays can be introduced to control the duration of illumination, and the actual instant that it becomes illuminated during the eye movement. In this way we can be sure that the symbol is illuminated only while the eyes are actually moving, and the subject can make an accurate report on what he saw while his eyes were moving. This type of study is of more than academic interest, because the amount of valid information a pilot or engineer obtains in a glance across a control panel is obviously of importance.

There are many other applications for the use of the eye as a control mechanism. Dials can be illuminated when a subject looks at them and switched off when he looks away from them, or areas of a television tube brightened or darkened as each area is examined. In medicine, visual-field defects can be simulated—defects such as central scotoma, in which there is an area of blindness in the centre of the visual field (i.e. when the subject or patient looks at something it disappears), or hemianopsia, where vision exists only in the centre of the visual field.

Furthermore, in the clinical investigation of visual-field defects, continuous and adequate visual fixation can be ensured by arranging for the photocell corresponding to the point of fixation to control the stimulus, so that it can appear only while the patient is correctly fixated. In this way we could make quantitative assessment of fixation in various types of poor vision and particularly in unilateral blindness due to amblyopia exanopsia or 'lazy eye'.

Here it would be especially useful in assessing the efficacy of treatment, particularly because of the recent advances in the field of pleoptics, which is a system of training for co-ordination between brain and eye, and in which methods of treatment are used which involve retraining to develop correct fixation points. It should also enable us to measure and perhaps to classify the types of nystagmus, which are involuntary rhythmical deviations of the eye occurring both in situations such as high-speed turns in aircraft and in a variety of diseases.

Summary

The television eye marker demonstrates eye movements by viewing the corneal reflection with one television camera and scene with another, and presenting the combined outputs as a composite picture. In this the point of regard is shown as a white spot, which can also be used to activate photocells. These in turn can drive a teletype machine recording the movements, or operate circuits to control the visual input to the subject.

Power-station efficiency

THE Central Electricity Generating Board saved £2·69 million in fuel costs during 1959. Over-all average efficiency of the power stations operated by the Board rose to 26·36% from 25·99% for 1958. Almost a third of the total 90828 million kWh was supplied by the 20 most efficient stations, which had an average thermal efficiency of 30·67%, the first three being Blyth A (33·88%), Agecroft C (32·63%) and Castle Donington (32·52%).

CULHAM RESEARCH ESTABLISHMENT

CONSTRUCTION work has been started on the first of the laboratories at Culham, Oxfordshire, for the United Kingdom Atomic Energy Authority's research on controlled thermonuclear reactions and plasma physics. The first batch of buildings to be erected will accommodate the large facilities needed for I.C.S.E. (Intermediate Current Stability Experiment) and its associated services. The remainder of the research being transferred to Culham is expected to be accommodated within the next two years or so.

681.142 : 621-52

COMPUTERS AND CONTROL SYSTEMS

In this article the author outlines two applications of computers to control systems. In the first example he considers a computer which derives input instructions for a control system, and in the second he describes how computer technique is employed to organize appropriate controls in one system.

This is founded on part of the Chairman's Address delivered to the North Staffordshire Sub-Centre by the author on the 9th October 1959 at Stone. (A report of this meeting appeared in the January 1960 Journal, p. 59.) Mr. Asbury is with the English Electric Co. Ltd.

A. ASBURY, B.SC., MEMBER

THE technique of control-system design is now established for most practical applications, and further developments using computers and computing methods are being considered. The computer may be used to derive the appropriate instructions for the system, or to organize the control system to give optimum performance, changing the nature of the system as necessary.

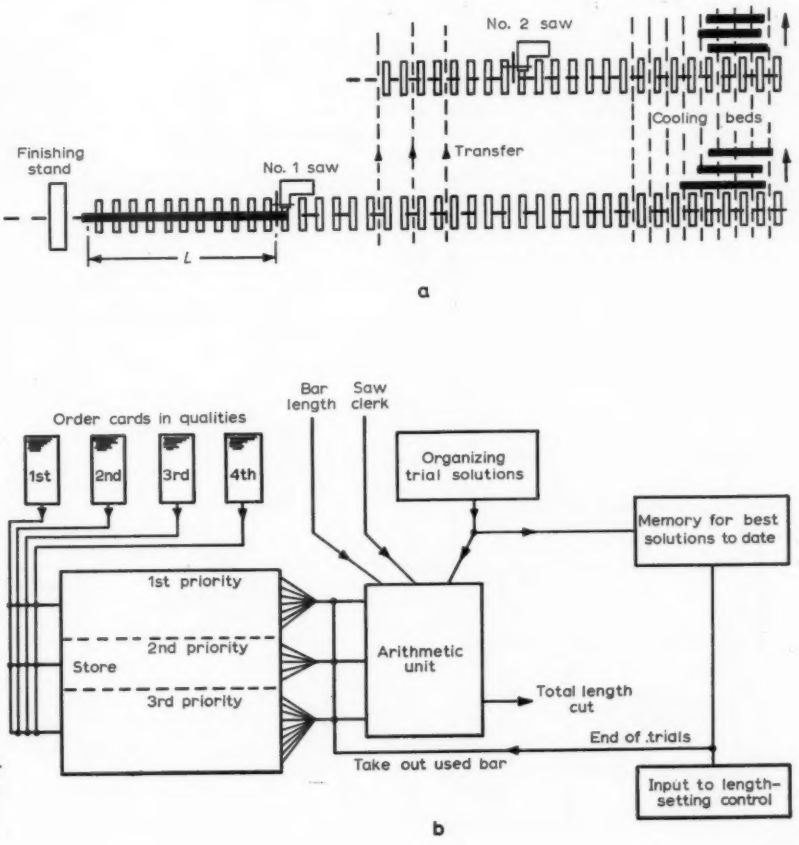
Computing information for control systems

The former requirement is likely to arise where essential data are not available until shortly before the command is required for the control system. A good example of this is shown in Fig. 1a, which indicates the lay-out of a saw bench. When the steel is rolled from the last stand, its length must be determined before the saw clerk can decide the lengths he must cut from each piece. This measurement can actually be made while no. 1 saw is trimming the nose end, and some allowance is made for the waste expected at the tail. The saw clerk is provided with a list of orders for different customers, detailing the number of pieces and the length of each. He must then decide which pieces to cut so that the amount of waste is as small as possible.

In this particular equipment it is also necessary to save some of the work for no. 2 saw, and this is arranged by cutting off an exact length for an order, and transferring it to the table for no. 2 saw. When the pieces are cut they pass on to the cooling bed, where the pieces for a particular customer's order are gathered together for shipment. This sorting is more difficult if the saw clerk uses pieces from a large number of orders, and can be a limit to the production rate.

The problem may be further complicated in that customers require different grades of steel, and the particular grade being rolled can be supplied only to certain customers. Finally, it is sometimes necessary to arrange for test-pieces to be cut from the bar. All these requirements make the job of the saw clerk very difficult, especially since he is expected to make his decision in two or three seconds.

Fig. 1b shows in schematic form the equipment required for this purpose. The order cards are arranged in their qualities, and card-reading equipment enables the details of the orders to be stored in the computer. These are arranged in a manner which enables the computer to fulfil the functions mentioned above, and



1 *Use of computer to derive instructions*
a saw-bench arrangement
b equipment required for computer system

the computer systematically organizes trial solutions of the possible orders to fit the length of the piece which has just been rolled. As each solution is considered, the best so far is remembered. At the end of the trials, this solution is examined to see if it is satisfactory, and, if so, it can be passed to the cut-length control and also displayed for the benefit of the operator. The computer must now remove these items from the store to be ready for the next piece.

A possible refinement is the introduction of a modification to the computer programme depending on the state of the control system itself or other related equipment. For example, normal operation of the computer may give a spread of cut pieces over orders which can be handled by the cooling beds and cranes. If one crane were temporarily out of service, however, the programme of the computer could be modified to restrict the spread over orders at the expense of extra waste. In this and similar ways the computer can give the properties of adaptation or optimizing.

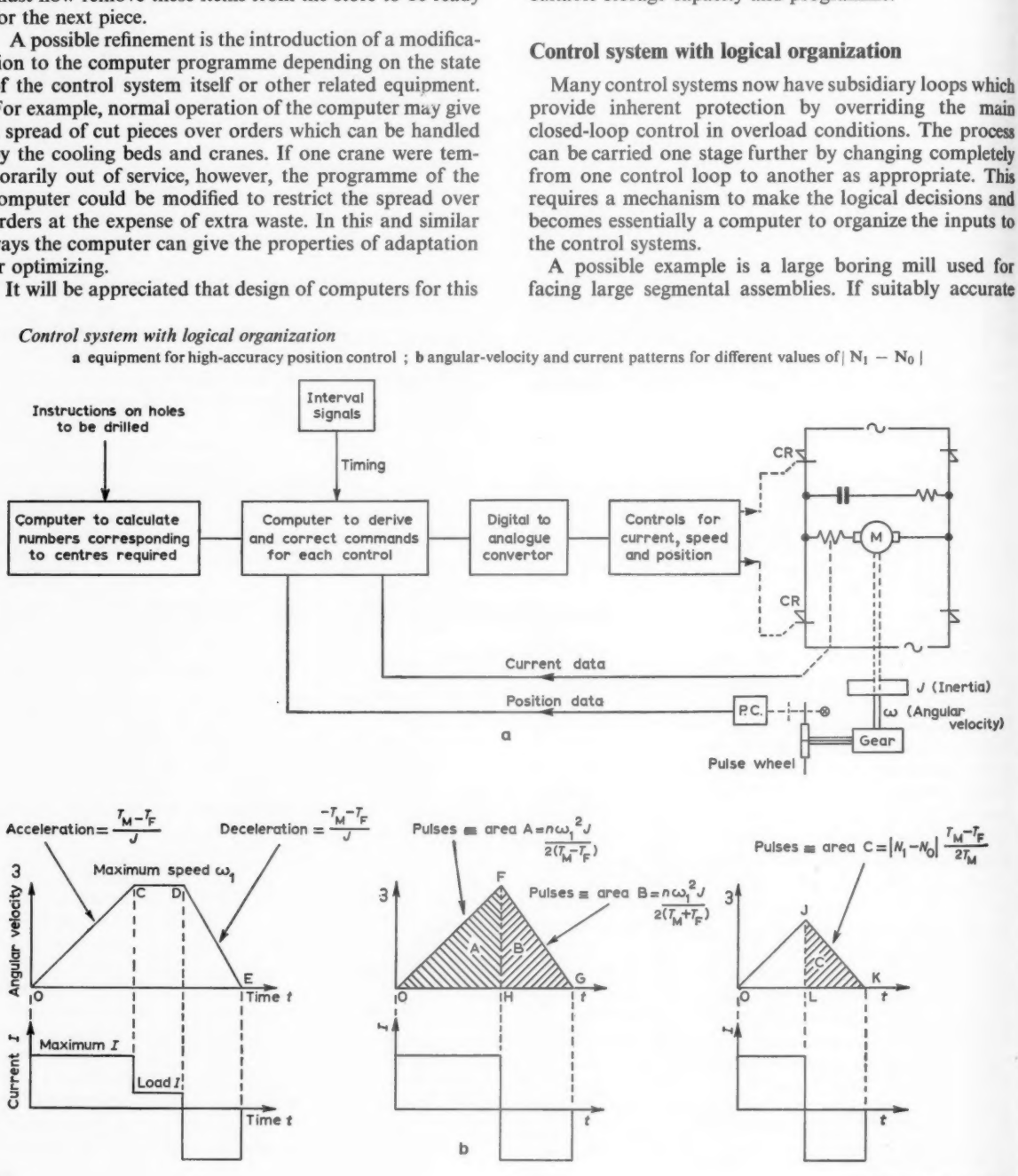
It will be appreciated that design of computers for this duty must relate the cost of the computer to that of the wasted product. A very expensive computer would be necessary to give the minimum possible waste. To investigate the balance between performance and cost, the general-purpose computer Deuce has been made to operate like a saw-bench computer. Different internal arrangements have been considered to decide the most suitable storage capacity and programme.

Control system with logical organization

Many control systems now have subsidiary loops which provide inherent protection by overriding the main closed-loop control in overload conditions. The process can be carried one stage further by changing completely from one control loop to another as appropriate. This requires a mechanism to make the logical decisions and becomes essentially a computer to organize the inputs to the control systems.

A possible example is a large boring mill used for facing large segmental assemblies. If suitably accurate

2 *Control system with logical organization*
a equipment for high-accuracy position control ; **b** angular-velocity and current patterns for different values of $|N_1 - N_0|$



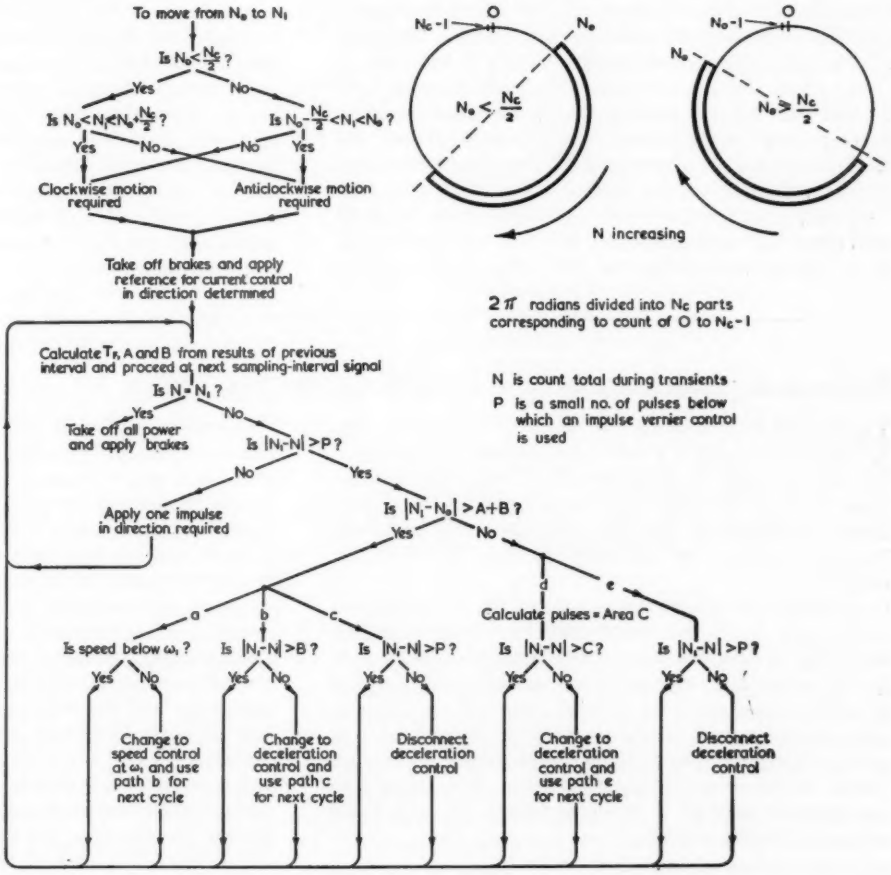
angular positioning can be provided, these assemblies could be faced and marked out on the boring mill, so avoiding the need for reassembly. Such a drive has large inertia and requires accurate positioning with minimum settling time. A simplified scheme for this purpose is shown in Fig. 2a, and the computer is shown providing instructions to the controls via a digital-to-analogue convertor.

The position of the table is measured by feeding pulses from an interrupter disc into a reversible counter which therefore holds a number representing angular position. Speed measurement is obtained by counting the pulses in a given interval.

Fig. 2b shows the possible angular-velocity patterns which occur depending on whether a large or small movement is required. In the left-hand pattern the maximum speed is reached, the centre shows the limiting case where the maximum speed is just attained, and in the third case limiting speed is not reached. In each it is assumed that the torque supplied by the motor is the maximum allowable, and this is represented by T_M. The friction torque is represented by T_F, and on this basis acceleration, deceleration and the areas A, B and C can be calculated from the formulae of Fig. 2, where n is the number of pulses per radian of the boring-mill table.

During acceleration a calculation can be made to correct the assumed value of T_F so that subsequent use of this value will give more-accurate results. At the point C it will be necessary to modify the current control and substitute a speed control to hold the maximum speed, ω_1. At D the control system will need to be instructed that this is the last possible instant in time at which deceleration can reach the required position. The area is calculated using the value of T_F just found and the known inertia of the system. Fig. 3 shows the logical steps involved and demonstrates that other problems must first be considered.

It is desirable that the table take the shortest travel to its required position. If we assume that the present position is N_0 and it is required to move to N_1, the direction of rotation can be found by asking two questions in turn. First we must decide whether N_0 is in the first half of the semicircle, and second whether N_1 falls in the appropriate half-circles starting from N_0. Bearing in mind that the position information is a number, some ambiguity can arise if the best direction of motion involves changing from the maximum count to zero and counting positively


To move from N₀ to N₁
Is N₀ < Nc/2 ?
Yes
No
Is N₀ < N₁ < N₀ + Nc/2 ?
Is N₀ − Nc/2 < N₁ < N₀ ?
Yes
No
No
Yes
Clockwise motion required
Anticlockwise motion required
Take off brakes and apply reference for current control in direction determined
Calculate T_F, A and B from results of previous interval and proceed at next sampling-interval signal
Is N = N₁ ?
Yes
No
Take off all power and apply brakes
Is |N₁−N| > P ?
No
Yes
Apply one impulse in direction required
Is |N₁−N₀| > A+B ?
Yes
No
a
b
c
d
e
Calculate pulses = Area C
Is speed below ω₁ ?
Is |N₁−N| > B ?
Is |N₁−N| > P ?
Is |N₁−N| > C ?
Is |N₁−N| > P ?
Change to speed control at ω₁ and use path b for next cycle
Change to deceleration control and use path c for next cycle
Disconnect deceleration control
Change to deceleration control and use path e for next cycle
Disconnect deceleration control
N₀ − 1
O
N₀
N₀ ≤ Nc/2
N₀ − 1
O
N₀
N₀ ≥ Nc/2
N increasing
2π radians divided into Nc parts corresponding to count of O to N₀ − 1
N is count total during transients
P is a small no. of pulses below which an impulse vernier control is used

3 *Logical steps of control system*

again. This is avoided by the questions shown in Fig. 3.

First we ask whether N_0 is greater than $\frac{1}{2}N_C$. If it is not, we can then consider the half-circle formed by adding $\frac{1}{2}N_C$ to N_0 and see whether the new position required is in this semicircle. If, on the other hand, N_0 is greater than $\frac{1}{2}N_C$ we ask instead whether the new position is in the semicircle working backwards from N_0. It is now possible to apply the appropriate current reference to give motion in the direction required. The sampling interval is small, and it is therefore allowable to wait until the next sampling-interval signal is received.

Logical sequence

We will consider first the sequence for a large movement; its logical steps are indicated on the lower left-hand side of Fig. 3. After a few intervals it will be possible to calculate the friction to modify a starting figure and so obtain improved values of A and B. The next step is to check that the remaining movement is still greater than the range of the pulsing control, and, until it is, the process passes on to the basic question 'Is $|N_1 - N_0| > (A + B)$?'.

In this example the answer is 'yes', and the pattern of operation shown in the lower left of Fig. 3 is chosen. This leads to three alternative paths a, b and c, which are used in that sequence. At first the control is still causing acceleration, and the question 'Has speed reached ω_1?' ensures that the sequence passes to the next sampling interval until the maximum speed is attained. At this point a change to speed control is required, and subsequent cycles for this control use path b.

Operation at speed ω_1 will now continue as required until the point of deceleration is reached. This is detected by a mechanism asking 'Is $|N_1 - N| > B$?', and is arranged to change to current control giving maximum deceleration when the conditions of point D or F of Fig. 2b are reached. Deceleration now continues for each cycle using path c until the table is within the range of the pulsing control. Then the braking current is removed, and subsequent cycles use the pulsing-control cycle given by the negative answer to the question 'Is $|N_1 - N_0| > P$?'. This continues until finally $N = N_1$, and the process is terminated by applying the brakes.

If the angular distance to be moved is much smaller, a simpler process is appropriate. The question 'Is $|N_1 - N_0| > (A + B)$?' now selects the right-hand section of Fig. 3, and it is necessary to calculate the number of pulses corresponding to the area C of Fig. 2b. The control sequence follows a pattern similar to the previous one except that the full speed control is omitted.

From this example it will be seen that a number of controls can be co-ordinated by a logical process and the method applied generally. The process of measuring and comparing inherent in simple closed-loop controls is replaced by discrimination between controls on a logical basis.

Summary

The use of computers in control systems can be regarded as an extension of the power of the system to discriminate beyond direct dependence on the difference between input and output. Where a computer derives the appropriate input it may also accommodate change in the task by varying the control system. The development of systems organized by computers offers possibilities of the best performance with power to use all modes of operation. Of philosophical interest is the fact that this last development replaces the conventional closed loop by a loop closed only by logical decisions, the main control loop being all but open.

Prospect of greater commercial freedom for the Post Office

PROPOSALS for improving the status of the British Post Office are outlined in a recent Government White Paper.* The chief features are the separation of Post Office finances from the Exchequer and the replacement of the present annual Parliamentary Estimate procedure and associated Treasury control by a more flexible Parliamentary control.

At present, Post Office revenues are paid into the Exchequer, which issues money required to meet Post Office costs. The Post Office is thus, like other Government departments, subject to traditional controls which aim to regulate the spending of public money raised by taxation, although, unlike those departments, it lives on what is spent by the public on its services. The public pay more than £400 million annually on postal, telephone and telegraph facilities, and taking into consideration payment of pensions, savings, etc. over £5000 million is handled annually.

* Cmd. 989 'The status of the Post Office', H.M.S.O., London. 6d.

The recommendations mean that the Post Office would be free to make quick decisions, to innovate and to develop its business. It would remain a Government department and be directly represented by a Minister in Parliament, and staff would retain their status of civil servants.

A statutory Trading Fund would be set up into which all Post Office receipts would be paid and out of which expenses would be met. Appropriation accounts, showing estimates for annual cash requirements, would be discontinued, and the existing system of annual commercial accounts, giving the over-all trade position for the year and the profit or loss on various services, would be accompanied by a report from the Postmaster General, which is in line with modern commercial practice.

Borrowings of new capital would still have to be authorized by Acts of Parliament. The Post Office at present finances—through its provision for depreciation—just over half its annual needs for renewal, modernization and expansion.

Education in the United States for changing times

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American education is seething, with rapid improvement in the upper levels of high-school achievement, great emphasis on science teaching, and wide expansion of graduate study. The new trends are discussed in this article by Mr. Alger, who is Adjunct Professor, Rensselaer Polytechnic Institute, Troy, New York, U.S.A.

Prof. PHILIP L. ALGER, MEMBER

THE engineer being the apostle and creator of change, his education should run ahead of other progress. His educators must aim at a moving target, to mould their students for leadership 30 years hence, when conditions will be vastly different from those of today.

How different they will be, and in what manner, may be inferred by scanning changes that have occurred in the past. Consider travelling in England, for example. In the year 1741, Col. Liddell, setting out from London on the 200-mile journey to Harrogate, offered a blind man (John Metcalf, later a famous road-builder) a seat in his coach. The blind man thanked him, but declined the offer, observing that he could with great ease walk as far in a day as the Colonel was likely to travel in his carriage; and besides, he preferred walking.

Metcalf started on a Monday morning, an hour before the Colonel in his carriage; and he arrived first at Welwyn, the appointed stopping-place for the night. Each day the blind man was ahead. On Saturday, they reached Wetherby, and the Colonel decided to stop for two days' rest; but Metcalf continued on the next day to Harrogate, arriving in six days, as against the Colonel's eight.*

A mere listing of the inventions that have come into use recently, from antibiotics and atomic energy to radar and moon-shots, shows that the stream of change flows ever faster, and the beneficent role of the engineer grows ever more important. In the words of Herbert Hoover†: 'To the engineer falls the job of clothing the barebones of science with life, comfort, and hope. No doubt as years go by some people forget which engineer did it, even if they ever knew. Or some politician puts his name on it. Or they credit it to some promoter who used other people's money to finance it. But the engineer himself looks back at the unending stream of goodness which flows from his successes with satisfactions that few professions may know.'

To meet this challenge of continual change, engineering education in the United States is moving along four distinct paths.

Education is an open-end road

We used to teach subjects independently, allowing students to feel that they were going up a succession of dead-end roads, and that they could burn each book in turn as its final examination was passed. Now we try to present each topic as an open-end road, with enticing new vistas always coming up ahead.

As one professor told me, we used to have young biology students dissect a frog, a chicken, and a rabbit. That was that. Now we explain that biology is the study of life, and that living things depend on circulation systems, which require pumps, channels and controls. Then we trace the evolution of these elements from the amoeba, and we regard each creature that is examined as merely an example of a certain stage of progress. Thus we hope that graduates will understand the relations of things, will accept change, and will be led to continue their studies through life.

An example of this trend in engineering is the revolution that is occurring in teaching electrical machinery and power courses. Formerly, we considered induction, synchronous, and direct-current machines and transformers in turn, with little regard for their common elements. Now we say that all such machines are merely examples of devices to convert energy from one form to another.

Following Gabriel Kron's ideas, we consider that all are obtained by making particular sets of connections of the windings of a 'primitive' or 'generalized' machine, with appropriate changes in the mechanical structure. And, following the lead of the Massachusetts Institute of Technology, we say that the operation of any of these devices is defined by the Lagrangian equations of energy storage and exchange between mechanical, magnetic, electrical and thermal sources.

One procedure is first to derive the general equations, considering all the energy sources and sinks, and then to obtain equations for a particular case by putting in zeros and other simplifying conditions. Another procedure is first to consider simple cases, and then to add elements needed to cover the more complex devices, one by one. In either case the new ideas are described by the term 'dynamic circuit theory', which forms a natural extension of ordinary (static) circuit theory.

Teach systems, not elements

A second path that is a natural offshoot of the first is to consider each theory, or element, as simply a part of an entire system. We consider the mechanical along with the electrical behaviour of any machine, the voltage regulator along with the generator it controls, and the speed governor along with the turbine.

In the realm of circuit theory, we used to consider first direct-current behaviour of a simple circuit, then steady-state alternating-current, then look into more-complex

* From Samuel Smiles's 'Life of Metcalf' in the series 'Life of the engineers' (Murray, London, 1861–67)
† 'Memoirs, 1874–1920' (Macmillan)

circuits, and finally consider high-frequency and transient behaviour. Now we study the whole response of a circuit; with its behaviour on direct current, on alternating current up through the range of megacycles per second, and on impulse, as merely different aspects.

System response, feedback control, and automation processes are steadily gaining in attention. More and more students are taking courses in programming and use of computers. Electrical engineers are extending their studies to include manufacturing processes, production scheduling, and economic system behaviour, with the aid of analogue and digital computers.

Student motivation is all-important

The third trend is a growing reliance on student motivation. It is said that an American high-school student today can find time to do literally anything if he wants to do it, but he cannot possibly find time to do anything he does not want to do. The same applies even more forcibly to college students. Thus the effort is made to enlist the student's enthusiasm as a driving force behind his studies, and to allow departures from routine procedures whenever the student shows adequate motivation.

This is in line with British tradition, as indicated by the inscription on the memorial tablet at Rugby, which speaks with approval of the '. . . fine disregard for the rules of football as played in his time . . .' (1823), whereby Ellis created the Rugby game.

An interesting example of this is a 7-week summer course in science* at the Loomis School in Windsor, Connecticut, given by Vincent J. Schaefer to 30 high-school juniors recently. Each boy was offered his choice of 68 experimental projects, the offshoots of the teacher's work in surface chemistry and meteorology (with Irving Langmuir) over the past 20 years. More than 80% of these projects carried on by 15–17year-old boys produced new scientific information, and one-third resulted in new discoveries.

One boy, Steve Caldwell, chose to examine 'the effect of organic vapors on ice-crystal structures'. To provide a source of ice crystals, he filled porous plastic casings with salt water, and exposed them in a cold chamber. To his astonishment, long white hairs grew out of the casings, which proved to be perfect crystals of salt, similar to the metal whiskers that scientists have found to have amazing strength and purity. This 'serendipitous' result has excited great interest in scientific circles, and, perhaps more important, it has given Steve a conviction that, 'work is fun and there are few things more exciting than learning'.

Graduate study is in fashion

The fourth trend is a great increase in postgraduate study. Nowadays, a bachelor's degree is coming to be regarded as hardly more than a hunting permit to seek further education elsewhere. One of the most difficult questions facing the student today is how and where to pursue his education beyond the first degree. In the United States there are four accepted procedures:

(a) The student takes up full-time graduate study immediately following his undergraduate years, often at another institution. From the student's viewpoint, this is attractive because it saves time. When the student has a well defined and challenging objective, good results accrue, but it is not good if the student has no adequate plan. However, few students can afford the cost of this 5- or 6-year programme.
(b) The student takes up part-time teaching along with his graduate study immediately following his undergraduate years. From the institution's viewpoint this is a satisfactory method, because it provides teaching assistants of high quality at low cost. Furthermore, the student gains some maturity before his final choice of thesis project, and he also has more flexibility in his programme. On the other hand, both study and teaching suffer from the student's divided loyalties.
(c) The student enters employment immediately following his undergraduate years, and later takes up part-time graduate study, either in the evenings or at stated periods alternating with regular work, under some co-operative plan. This method has been highly developed in alternative forms, and has been successful on the whole. However it lacks the great value of out-of-class associations with university people. And it is not satisfactory when the student transfers from place to place, as many employers now require; or when the place of employment is far from an appropriate educational institution.
(d) The student enters employment for a few years and then takes up full-time graduate study for an extended period. This method, just coming into use, provides graduates of the highest quality. However, it interrupts the student's career, and family responsibilities may make it very costly.

In American conditions of early marriage and widely available assistantships, method (b) will no doubt continue to be the most popular. In both (a) and (b) the effort is made to enlist the help of industry and practising engineers in selecting worthwhile theses, and relating study to useful economic purposes. Method (c) is expanding steadily, with a great many alternative forms on trial. Method (d) is gradually gaining in importance. It is my view that this last method is the best way of creating really top-level engineers and scientists, and that it should be used much more widely. However, industry or Government financing is required, and this can be given only to exceptional candidates.

More and more science for engineers

An engineer needs to know why a process works, not merely how to apply it. If he knows why, he can understand, devise and apply many other processes. If he only knows how, each process must be learned

* *Saturday Review*, 12th December 1959, p. 51

separately, and he can hardly rise above technician level.

Thus, as Welbourn has remarked:

'The proper function of universities is the teaching of analysis; and design, or synthesis, belongs properly elsewhere.'

In line with this principle, American universities are dropping all kinds of practical subjects, such as drawing, machine design, and 'skill courses', which are now being given in high schools and technical institutes, or in industry training programmes. In their place are going more physics, more mathematics, and more science courses.

Dr. Vannevar Bush said recently that, to be a cultured gentleman, among other things, one should know solid-state physics. However this may be, the arrangement of electrons in atomic shells, the laws of quantum mechanics, and field theory are being more and more widely taught, and are moving down from graduate levels into courses for juniors or third-year men.

Summary

Thus, on the one hand, skill courses are being pushed aside; and, on the other hand, new science courses are being pushed in at the bottom of the college curriculum. One may say that glacial erosion and volcanic upheavals are taking place at the same time throughout American engineering education. The normal accredited college engineering course is becoming science-oriented. The postgraduate courses are not well defined, but they are shaping up in two distinct forms. One is towards the Ph.D. degree for high-level research and development careers. The other is towards a professional engineering degree for designing and operating careers, with a growing share of the instruction given in industry-sponsored courses.

Commonwealth telecommunication

OPENING the third technical and traffic meeting of the Commonwealth Telecommunications Board on the 3rd May 1960 in London, the Postmaster General said that internal communications in the United Kingdom—postal, telegraph and telephone—were moving rapidly towards automation, and he was confident that, with close co-operation, similar progress in external telecommunications could be expected. The basic purpose of the meeting, he said, was to discuss technical development and improvement of those external communications. Similar meetings were held in 1950 and 1955. The Board was established in 1949, in pursuance of the Commonwealth Telegraphs Agreement of 1948, to advise partner Governments to that agreement on their joint telecommunications policy.

Since the last meeting, the first transatlantic telephone cable, a joint enterprise of the United States, Canada and the United Kingdom, had been laid. Plans were well in hand for the construction of the second major link in the Commonwealth telephone cable network linking Canada, Australia and New Zealand.

The Postmaster General went on:

'The challenge of high-speed large-capacity cable systems has been matched for radio by a development that will ensure a long-continuing use of radio for telegraph communication. I am thinking especially of those ingenious devices—known, I am told, by the appropriate and cryptic letters ARQ—which automatically correct errors that inevitably arise with atmospheric conditions causing signals to be mutilated.

'This development has greatly improved the reliability of radiotelegraph communication and allowed us to use radio for services such as international telex on a far wider scale than we had earlier thought possible.'

A report of the meeting, which lasted three weeks, will be made to the Governments. A main feature was the problems of mechanization in the international telegraph services.

Work started on Dragon reactor

AFTER a simple inauguration ceremony on the 27th April 1960, construction of the experimental reactor for the O.E.E.C. Dragon project began at Winfrith, Dorset. The 20 MW high-temperature gas-cooled reactor is being built by an international team drawn from the United Kingdom and 11 other European countries, and will be ready for operation in 1963. The joint research and development project, which was agreed on in 1959 and covers a period of five years from April 1959, will help to lay the foundation for the commercial application of this type of reactor for the generation of electric power.

During the ceremony, a steel cylinder containing plans of the reactor, a copy of the project agreement, and coins from the signatory countries was laid in the concrete foundation slab of the reactor building by Dr. Sigvard Eklund of Sweden, Chairman of the Dragon Board of Management. Representatives of participating countries included Sir William Penney, Member for Research of the United Kingdom Atomic Energy Authority and Vice-Chairman of the Board of Management of the project; Dr. J. Gueron, Director-General of Research, Euratom, and Chairman of the General Purposes Committee of the project; Dr. A. F. Fritzche (Switzerland); Dr. M. Higatsberger (Austria); Mr. E. Jansen (Norway); and Mr. F. Juul (Denmark). The O.E.E.C. European Nuclear Energy Agency, under whose auspices the reactor is being built, was represented by Mr. E. Saeland, Deputy Director of the Agency.

During the first year of the project, the main objectives were the building up of the necessary scientific, engineering, administrative and supporting staff, the initiation of the research and development programme, a review of the proposed design of the reactor experiment, and finally the start of work on the reactor experiment itself.

Following the ceremony, Mr. D. W. Fry, Director of the Atomic Energy Establishment, Winfrith, presented Dr. Eklund with a silver trowel to commemorate the occasion.

An electrical engineering review

SOME RECENT DEVELOPMENTS IN TRANSISTORS AND RELATED DEVICES

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The range of semiconductor devices and their fields of application have been greatly extended by exploitation of possibilities latent in the basic junction transistor. Among other developments, modification of device structure has led to triodes capable of v.h.f. amplification (drift transistors) and, at the other extreme, power control (4-layer controlled rectifiers).

The properties and applications of the wide variety of devices now available are indicated in this article, which, to some extent, draws on material presented at The Institution's transistor convention held in May 1959, though not specifically. Dr. Boothroyd is in the Department of Electrical Engineering, Imperial College of Science and Technology, University of London.

A. R. BOOTHROYD, B.SC.(ENG.), PH.D., GRADUATE

An earlier article in the *Journal** reviewed briefly the physical arrangement, mechanism and applications of the junction transistor. The present article is intended as a sequel: it conducts a more detailed examination of the transistor in its basic form and discusses some important recent device developments that have resulted from exploitation of its inherent mechanisms and structural possibilities.

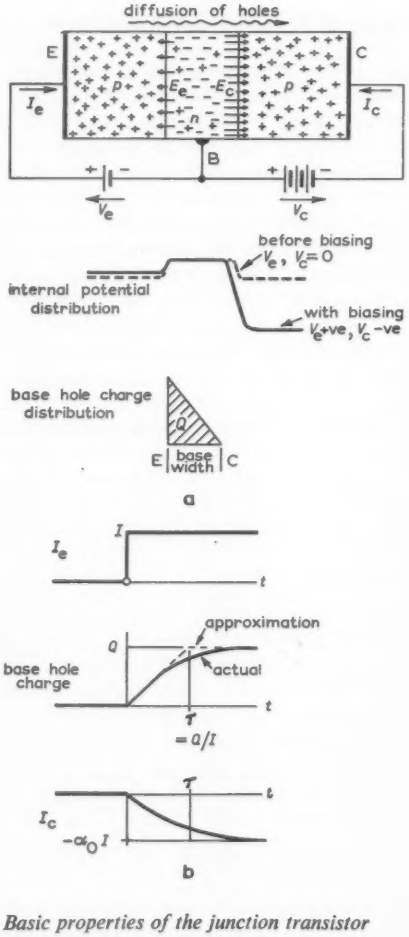
The basic junction transistor

The general arrangement and *modus operandi* of the junction transistor will be assumed familiar, as outlined in the earlier article, though it is convenient to restate the transistor mechanism in a somewhat different manner. Consider the *p–n–p* transistor, shown diagrammatically in Fig. 1, in which the emitter and collector *p*-regions contain holes as positive charge carriers, while in the base *n*-region electrons act as negative charge carriers.

The respective charge concentrations may be visualized as a 'gas' of positive or negative charged 'particles' undergoing random motion under the influence of thermal activation. In the absence of applied bias voltages, the tendency of holes to diffuse into the *n*-region and electrons into the *p*-regions is just balanced by the repulsive action of the electric fields associated with internal potential barriers across the *p–n* junctions. These potential barriers are indicated in Fig. 1.

When operated as an amplifier, external bias voltages V_e (positive) and V_c (negative) are applied to the transistor such that the internal potential barrier across the emitter-base junction is reduced, and that across the collector-base junction increased. The emitter and collector rectifying junctions are thus forward- and reverse-biased respectively.

On reducing the potential barrier across the emitter-base junction, holes are 'injected' from the emitter to the base region by the process of random diffusion, causing the base to acquire a positive charge of holes; this charge is just balanced by a negative charge of electrons drawn in at the base terminal. Similar injection of electrons from the base to the emitter region is negligible because the



1 *Basic properties of the junction transistor*
a essentials of transistor mechanism
b base charging and collector-current response

* WOLFENDALE, E.: 'The junction transistor and its application', *Journal I.E.E.*, 1958, 4, p. 583

density of electrons in the base is very small compared with that of holes in the emitter material.

Associated with charging of the base is the diffusion of holes *through* this region to the collector until, in the steady state, no further increase in base charge takes place and a fraction α_0 of the emitter current flows to the collector, the remainder being lost by recombination of holes with electrons. Since holes take a certain time to diffuse through the base region, owing to the 'random spreading' nature of the diffusion process, the collector current and base charge reach equilibrium values some time after the change in emitter-junction biasing conditions: the narrower the base, the shorter this time of response.

The transistor mechanism can be summarized as follows (see Fig. 1b):

(a) emitter current I_e, corresponding to forward-biasing of the emitter–base junction, results in an increase $+Q$ of the hole charge, and $-Q$ of electron charge, in the base region
(b) the base takes approximately a time $\tau = Q/Ie$ to reach charge equilibrium after a step change of emitter current
(c) the collector current rises to an equilibrium value $-\alpha_0 I_e$, with approximately exponential waveform of time-constant τ, where α_0 (the efficiency of base transport) is a little less than unity (e.g. 0·98).

The characteristic time τ may thus be regarded as representing either the base-charging or base-transit time; the value of τ sets a finite limit to the useful frequency range—or speed of transient response—of the transistor.

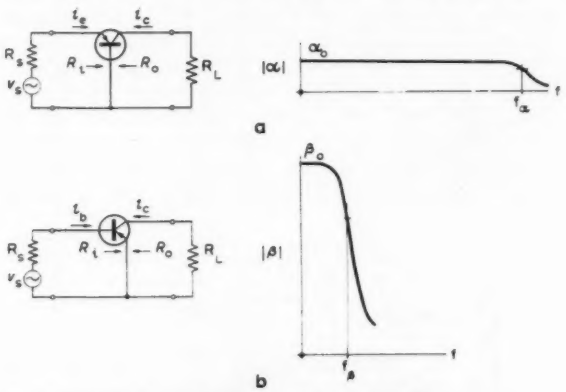
Power amplification

Arranged in the common-base configuration (see Fig. 2a), the transistor can provide power amplification because, although the current gain from input to output is less than unity, the emitter input resistance R_i is low (e.g. 100 ohms) while the collector output resistance R_o is very high (e.g. several hundred kilohms). However, at high frequencies the current gain of the transistor, and hence the power gain available, fall as a consequence of the finite base-charging or -transit time τ.

Corresponding to exponential collector-current response to an emitter-current step, the short-circuit current gain i_c/i_e may be written $\alpha = \alpha_0/(1 + jf/f_\alpha)$, where the α cut-off frequency $f_\alpha \simeq 1/2\pi\tau$, resulting in the frequency response of current gain shown in Fig. 2a. The power gain of the common-base amplifier must therefore be drastically reduced at high frequencies approaching f_α.

In the common-emitter configuration (see Fig. 2b), again R_o greatly exceeds R_i, but now the current gain is much greater than unity except at very high frequencies. The short-circuit current gain i_c/i_b now takes the form $\beta = \alpha/(1 - \alpha)$ or $\beta = \beta_0/(1 + jf/f_\beta)$, where $\beta_0 = \alpha_0/(1 - \alpha_0)$ and $f_\beta = (1 - \alpha_0)f_\alpha$. Thus at low frequencies β may be very large (e.g. 50) but, as indicated in Fig. 2b, the cut-off frequency f_β is much less than f_α. Large power gain, in general larger than for the common-base configuration, is possible mainly because of the large value of β_0, but the gain may now be reduced at frequencies approaching the comparatively low value f_β.

The above discussion emphasizes the fact that the frequency limitations of transistor amplifiers are defined by the base-charging or -transit time τ. For example, if $\tau = \frac{1}{8}$ microsec, $f_\alpha \simeq 1$ Mc/s; if $\alpha_0 = 0{\cdot}98$, $\beta_0 = 50$ and $f_\beta \simeq 20$ kc/s. By reducing τ the frequency response is improved, and this may be achieved either by reducing the base-width or by improving the mechanism of base transport, a more efficient process taking the place of random diffusion of current carriers. Transistors fabricated with very narrow base-widths may have values of f_α up to



2 *Common-base and common-emitter amplifiers*
Frequency characteristics of short-circuit current gains:
common-base $i_c/i_e = \alpha$
common-emitter $i_c/i_b = \beta$
a common-base circuit
b common-emitter circuit

about 50 Mc/s, but for further improvement the base-transport process needs to be improved in efficiency, as discussed later.

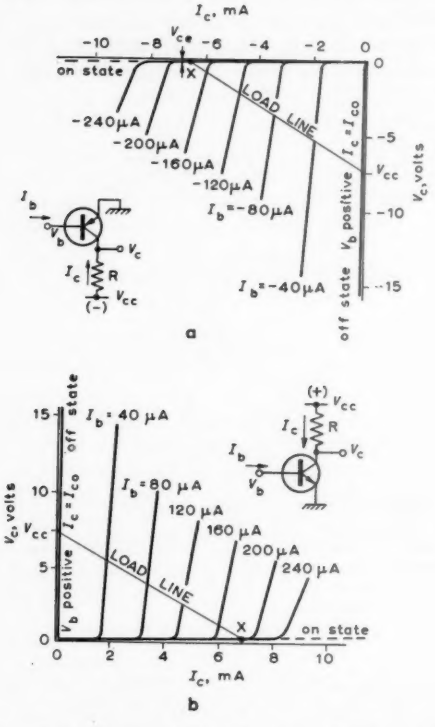
Transistor as a switch

A very important application of the transistor is as a switch; as such, it exhibits excellent properties, as may be seen by referring to the sets of common-emitter static collector characteristics shown in Fig. 3. If the base of a *p–n–p* transistor is taken positive to the emitter, the emitter–base junction is reverse-biased and the transistor put into an 'off' state with only a very small collector leakage current I_{co} flowing. For a germanium transistor I_{co} could be, for example, 1 μA, or only 0·01 μA for a silicon transistor of comparable general performance. Thus when 'off' the transistor closely simulates an open switch.

With the base taken negative to the emitter potential, such that sufficient (negative) base current flows, the transistor is turned 'on' and bottoms, at the point X on the load line in Fig. 3a, with only very small voltage between

collector and emitter. For example, with collector current values up to 1 amp the voltage V_{ce} may be not more than 0·2 volt in the 'on' state, while for negligibly small collector current, corresponding to switching or interrupting very small signals, V_{ce} may be of order as low as 1 millivolt. Clearly, when 'on' the transistor is a very good approximation to a closed switch and for many purposes may be considered ideal, with $V_{ce} = 0$.

It is interesting to note that the same device may operate well both as a small-signal amplifier, possibly at very high frequencies, and also as an efficient switch; it



3 *Static characteristics of p–n–p and n–p–n transistors*
a *p–n–p* transistor
b *n–p–n* transistor

follows, therefore, that it may be a fast-acting switch, and certainly there is no difficulty in accomplishing switching between the off and on states in times much less than 1 microsec.

Also shown in Fig. 3 are the static collector characteristics of a transistor of *n–p–n* type. In this case, the basic mechanism is the injection of *electrons* into the base region and their transport by diffusion to the collector, and, owing to the change of sign of the charge carriers, all operating currents and voltages are changed in sense as compared with the *p–n–p* transistor, as illustrated in the Figure. Thus a positive excursion of base potential, which would cause a *p–n–p* transistor to be put in the off state, may switch an *n–p–n* transistor on.

The versatility of switching circuitry is greatly increased by the existence of the complementary alternatives of *p–n–p* and *n–p–n* types of transistor, since for any polarity of base input control voltage it is possible to switch a transistor of one or other type into either the off or the on state.

A further very useful property of the junction transistor is that either of the electrodes denoted as 'emitter' and 'collector' by the manufacturer can actually function either as an emitter or as a collector; i.e. these electrodes can be interchanged and the device will still function as a transistor, though perhaps less efficiently in certain respects.

This property is evident from the symmetry of the diagrammatic representation of the transistor in Fig. 1. Thus when switched into the on state by flow of sufficiently large base current, the emitter and collector behave almost as if short-circuited together internally, and load current can flow through the transistor between emitter and collector in either direction—i.e. the transistor is a bidirectional switch.

The drift transistor

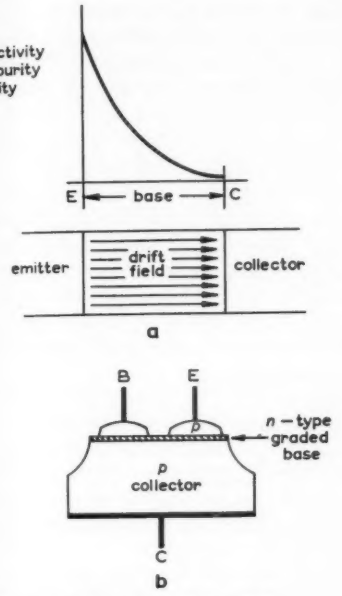
The above discussion of the junction transistor has been concerned with devices fabricated in the simple manner depicted in Fig. 1, consisting of a '3-layer sandwich' of *uniform* semiconductor regions of alternative type. The high-frequency limitations of this simple structure have already been indicated: the narrower the base, the better the high-frequency current-gain performance. It happens, however, that as the base-width is reduced to very small dimensions other electrical properties are affected adversely; for example, the maximum permitted voltage across the collector junction may become only a few volts.

A considerable improvement in the high-frequency performance of a junction transistor of given base-width may be achieved by increasing the efficiency of the base-transport mechanism. Transport by diffusion alone is relatively slow, and can be speeded up by so fabricating the base-region material that an electric drift field is 'built in', directed from emitter to collector. Charge carriers then drift in the electric field in addition to moving by diffusion, and the transit time from emitter to collector is considerably reduced.

For this purpose it is necessary to 'grade' the base conductivity from a high value at the emitter to a low value at the collector extreme of the base, as indicated in Fig. 4, and it may be shown that an exponential conductivity (or impurity) distribution results in a constant base field. Other benefits follow from such a base construction; for example, collector voltage rating is increased.

The most important recent development in device technology is the method of producing impurity grading in a semiconductor by a process of solid-state diffusion. Of the various possible procedures, the most commonly adopted is to expose a semiconductor sample, of uniform conductivity, to a vapour of the appropriate impurity (e.g. phosphorus for *n*-type impurity) in a diffusion

furnace. Impurity atoms diffuse into the crystal structure of the semiconductor, replacing original germanium or silicon atoms, and set up an impurity concentration that falls with distance of penetration. By this means extremely thin impurity regions of graded concentration distribution may be made with good process control.



4 *The graded-base or drift transistor*
a drift field in graded base
b 'mesa' transistor geometry

Transistors with the base fabricated in this manner are referred to as 'drift' or 'graded-base' devices. They may be made with cut-off frequencies f_α of several hundred megacycles per second, are capable of oscillating at frequencies even exceeding 1000 Mc/s and can be switched in a few millimicroseconds; as amplifiers they can give useful gain at tuning frequencies, or with video bandwidths, of at least 200 Mc/s.

A further important feature of the diffusion process of base fabrication is that it leads naturally to the adoption of the transistor geometry shown schematically in Fig. 4b (the so-called mesa geometry), in which the collector is a relatively massive block: in consequence, collector dissipation can be quite high even for transistors operating in the v.h.f. range, e.g. 0·1–0·5 watt for frequencies (f_α) of several hundred megacycles per second, or, with the same device structure, 5 watts at 10 Mc/s.

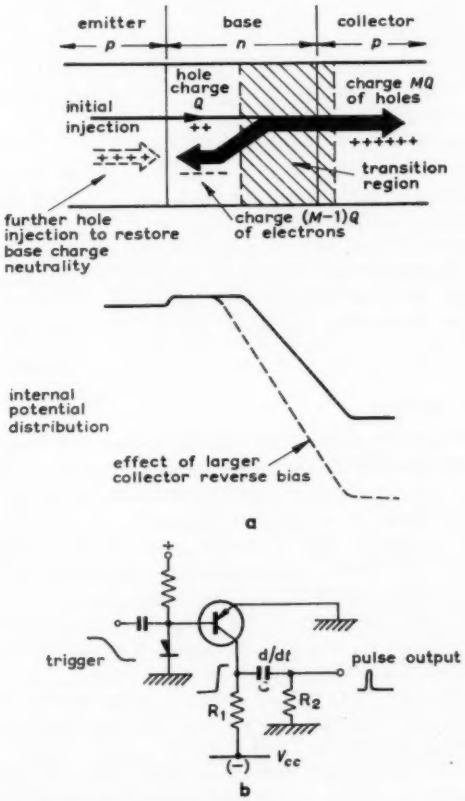
Avalanche switching

One of the most fascinating recent developments in the transistor field has been the utilization of an avalanche breakdown process for achieving ultra-high-speed switching. Avalanche breakdown, which has close similarity to the formation of a heavy-current (Townsend) discharge in an ionized gas, can occur in the field region of the collector junction of a transistor if the reverse bias voltage is sufficiently large; it is an undesirable effect in conventional operation of the transistor, and is avoided by limiting the working range of collector voltage.

The avalanche mechanism, and its possible benefits in connection with switching, can be explained simply in terms of Fig. 5a. The potential barrier due to collector reverse bias is developed across the 'transition' region, shown shaded, and as the reverse bias is increased two effects occur, both of which enhance the speed of response of collector current to injection of current from the emitter.

The first effect is an increase of the width of the transition region, entering more deeply into the base region, as indicated in the Figure, which reduces the effective base-width and hence the base-charging or -transit time.

In addition, avalanche multiplication of charge takes place in the transition region, as follows: holes injected by the emitter diffuse through the base region and, coming under the influence of the high electric field in the transition region, 'collide' with the semiconductor crystal lattice with sufficient energy to liberate



5 *Avalanche switching*
a avalanche-multiplication process
b avalanche trigger circuit

hole–electron pairs—i.e. to dislodge electrons, so creating holes in the crystal lattice: the holes augment the collector current and can cause α to exceed unity (an undesirable effect in amplifier operation of the transistor); the electrons, drifting in the opposite direction, enter the base region and set up a field which induces further charge-neutralizing hole injection from the emitter.

Thus avalanche multiplication can cause cumulative charging of the base, with consequent rise in collector current, the rate of which can be much higher than for charging by emitter injection alone. It is possible for the base charge and collector current to rise very rapidly indeed by this mechanism, the resulting rise-time being as small as 1 millimicrosec with conventional *p–n–p* transistors having an α cut-off frequency of some 15 Mc/s.

Application of the avalanche process

An example of a trigger circuit utilizing the avalanche process is shown in Fig. 5b*. The transistor is initially held cut-off owing to the presence of the base diode, but the collector supply voltage is so high that the base-width is very small and avalanche-multiplication conditions obtain; a defined collector leakage current flows, limited by R_2. On application of the base trigger pulse, the emitter injects holes, and collector current builds up rapidly by avalanche multiplication to a large value, limited by the transient load circuit components R_1 and C. With a suitable transistor, the output pulse length can be about 2 millimicrosec.

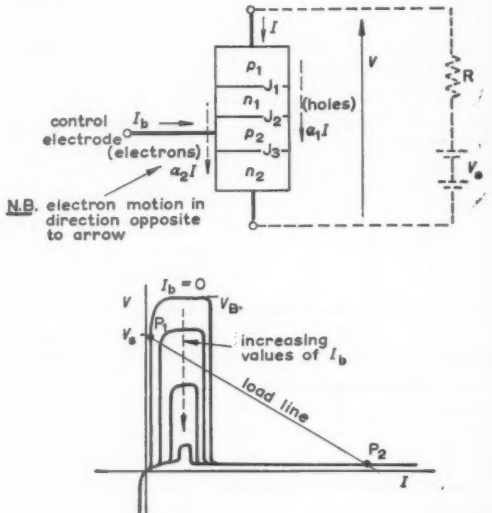
Although at present specifically designed avalanche transistors are not available, it is possible to select, from high-frequency *p–n–p* transistors made by a number of manufacturers, samples that are capable of switching in the manner described. As an example of the potentialities of such transistors, they have made possible a sampling oscillograph with an effective bandwidth of 300 Mc/s, capable of displaying a pulse of 1·5 millimicrosec rise-time*.

Four-layer devices

Since the earliest days of the transistor there has been considerable interest in the possibilities of a device of 4-layer *p–n–p–n* or *n–p–n–p* arrangement. Such a device may be simulated by connecting together a *p–n–p* and an *n–p–n* transistor, and a useful class of switching circuits has been derived in terms of this combination. It is only recently, however, that four-layer devices have been fabricated as such, using silicon as the most appropriate material, and that their great potentiality for power control applications has been appreciated.

Four-layer structures can be made in either diode or triode form, and they act as two-state elements capable of simulating closely an ideal open or closed switch; they can also switch very rapidly from the open to the closed condition, owing to the part played by avalanche multiplication in the switching process. In the triode form, the device is known as a 'silicon controlled rectifier'; it exhibits properties similar to those of the thyratron, though it is superior in a number of respects.

The operation and essential properties of the 4-layer structure may be explained in terms of the device arrangement of Fig. 6, disregarding initially the control electrode and considering the structure as a diode. The complete device is in effect a combination of two 3-layer 'transistors', one *p–n–p* (regions p_1, n_1, p_2) and the other



6 *The silicon controlled rectifier*
V_s = supply voltage

n–p–n (regions n_2, p_2, n_1), with an *n*- and a *p*-region shared; the shared regions n_1 and p_2 are bases. On increasing the applied voltage V from zero, junctions J_1 and J_3 are forward-biased and act as emitters, while the centre junction J_2 is reverse-biased by most of the voltage V and is a common collector junction for both 'transistors'.

Considering the upper *p–n–p* portion, the current I flowing into region n_1 is the sum of two components: a hole current $\alpha_1 I$ that traverses n_1 and flows through the collector junction J_2, and a 'base' hole current $(1 - \alpha_1)I$ that recombines with electrons within n_1. Thus electrons must enter region n_1 in order to provide for the recombination process, and the required electron supply enters n_1 via the junction J_2 as the current $\alpha_2 I$ resulting

* see CHAPLIN, G. B. B., and OWENS, A. R.: 'A method of designing avalanche transistor trigger circuits', *Proceedings I.E.E.*, paper 2944E, May 1959 (106 B, Suppl. 16, p. 806)

from injection of electrons by the emitter n_2 of the lower n–p–n portion of the device. For charge neutrality and current equilibrium in region n_1 (or region p_2), therefore, it is necessary that $(1 - \alpha_1)I = \alpha_2 I$ or $(\alpha_1 + \alpha_2) = 1$.

Now the current gains α_1 and α_2 include the influence of avalanche multiplication of current in the electric field of the reverse-biased junction J_2, the effect of which becomes more significant as V and I are increased. At a certain critical value V_B, known as the break-through voltage, the current multiplication in J_2 is so pronounced that α_1 and α_2 become too large for the equilibrium conditions to be satisfied and the current I rises indefinitely, corresponding to rapid charging of the centre regions n_1 and p_2 by avalanche charge multiplication: electrons and holes liberated at junction J_2 charge regions n_1 and p_2 respectively, so inducing further injection of charge carriers from emitter regions p_1 and n_2, with corresponding increase in I—a cumulative process.

With an external resistor in circuit, the diode switches to a high-current condition with all three junctions forward-biased and only a very small voltage drop across the device. The static voltage/current characteristics of the silicon 4-layer diode are shown diagrammatically in Fig. 6, corresponding to the case where the current I_b of the control electrode is zero.

Either of the base regions may be used for control purposes, and by varying the control current the voltage at which the device 'fires' is altered. With the region p_2 as the control electrode, in effect I_b supplies holes, making it more difficult for the condition for equilibrium of current in p_2 to be satisfied: this condition becomes $(\alpha_1 + \alpha_2) = 1 - I_b/I$. Thus break-through occurs for smaller values of V—i.e. smaller α_1 and α_2—as I_b is increased, as illustrated in Fig 6.

In the triode form, therefore, the 4-layer structure acts as a controlled rectifier. It may initially be stable at P_1 (see Fig. 6) with $I_b = 0$, functioning in a blocking role, but, on application of a positive pulse to the base control electrode, the flow of control current I_b causes rapid switching to the second stable state P_2 where the device acts almost as a short-circuit. In order to switch back to the initial state P_1 it is necessary to reduce the load current I sufficiently; in practice this requires V to be taken slightly negative for a short time.

The silicon controlled rectifier may be employed in applications for which a thyratron has been used in the past: for example, for a.c. power control, d.c./a.c. conversion, and for servo applications. To give some idea of presently available performance, peak inverse and maximum break-through voltages of several hundred volts and mean forward currents of tens of amperes are possible, with a maximum voltage drop of the order of 1 volt at a maximum forward current equal to about ten times the maximum mean current.

There would appear to be no reason why, as regards forward-current, peak-inverse-voltage and power-handling ratings, the controlled device should not have the same performance as its simple silicon-rectifier counterpart. Again, for similar ratings the physical dimensions of controlled and uncontrolled devices are approximately the same.

Summary

The junction transistor is a versatile circuit-element, capable of application both as an amplifier and as a switch. In either role its performance—frequency range of amplification or switching speed—is limited as a consequence of the base-transit time. In the drift transistor a base construction of 'graded' conductivity allows very short transit times to be realized, making possible operation in the v.h.f. range.

Utilization of an avalanche-multiplication mechanism, avoided in conventional transistor operation, enables ultra-high-speed switching to be achieved, with rise-times of only 1 or 2 millimicrosec.

A recent semiconductor-device development is the four-layer triode, or silicon controlled rectifier, which, with properties similar but superior to those of the thyratron, has important power control applications.

Whole-body monitor

THE Windscale works of the United Kingdom Atomic Energy Authority are shortly to acquire a device known as a 'whole-body monitor', which can be used to locate and measure the amount of any contamination which a person might suffer internally. The Dounreay experimental establishment will receive similar apparatus by the end of 1960.

The monitor, which is partly a research tool, contains four large scintillation heads using sodium iodide crystals and a smaller scanning head for locating the site of the contamination. It will be set up in a steel and lead-lined room to reduce background radiation. It can detect and allow for naturally occurring radioactive potassium when being used to identify other radioactive materials in the body, and with its high sensitivity will be able to measure in 5 min an amount of radium contamination equal to one-hundredth of the maximum permissible level.

Electronic store-keeping

AN electronic computer is to be installed at the R.N. Stores Depot, Copenacre, Wiltshire, for the purpose of mechanizing office work. The depot handles electrical, radio and Asdic stores for H.M. ships.

An up-to-date stock record of the 90000 different patterns of stores held at the depot will be kept on magnetic tape, as will lists of components for each of some 1500 different types of radio and Asdic sets to be fitted in ships. The machine will work out complete lists of components needed, check the stock record for availability, debit the stock record, and prepare printed invoices for items to be dispatched to the ships.

The computer will also be used to calculate future requirements of stores to be ordered from manufacturers, and to record resultant contracts placed and deliveries received.

Distribution substations 621.311.4:621.316.1

Much has been written of the efforts which engineers have made to produce and transmit electricity efficiently. The distribution engineer, however, has to provide and plan economically a public supply network to match the output produced.

One important aspect relates to the efficient planning, manufacture and installation of substation equipment, and the following article, which is based on part of the Chairman's Address to the Western Centre Supply Group on the 21st October 1959, reviews the present status and future trends in this field. Mr. Care is with South Wales Switchgear Ltd.

N. CARE, MEMBER

A MAJOR problem confronting the extension of distribution systems at the moment is the efficient siting of substation plant. The thousands of substations which have had to be installed, in many cases in areas already built up, have now possibly reached the position of saturation unless a fundamental change in the design and construction of plant is possible.

Pole-mounting and packaging

Perhaps the most important feature of substation practice has been the simplicity of the pole-mounted-transformer substation. Here we have achieved the ideal—an economical unit which can be installed at the load centre without any site difficulties—the only real limitation being the capacity of the unit. In this field we are much more economical than in Europe, where two-storey substations are very common.

In North America, overhead distribution is very common and as much equipment as possible is put on the pole structures—h.v. and m.v. lines, switchgear, and all the interposing transformers. We have followed this practice here to some extent, and the fitting of reclosers to overhead-line poles might be the forerunner to installing oil circuit-breakers in a similar manner. A leading British manufacturer has already produced a 3-phase 11 kV pole-top circuit-breaker, and we might in the future see a complete rural main-supply substation with all the switchgear accommodated on overhead-line structures.

For larger plant the Americans usually install package-type equipment in their effort to limit the site area occupied, and British designs of packaged substations have been supplied abroad where American practice is followed. With this design the maximum amount of assembly is carried out at the manufacturer's works, thus making site installation easy. The packaged substation is creating great interest in this country, in view of the ever-increasing demand for substations as near as possible to the load centres.

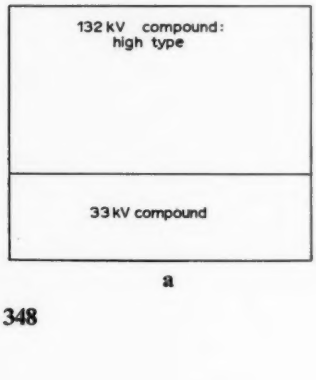
Bulk-supply points

First we must consider the main bulk-supply points where it is now common practice to operate our 132 kV system as a distribution network. Since Vesting Day about 200 132 kV bulk substations have been connected in England and Wales, and an effort has been and must still be made to simplify their design.

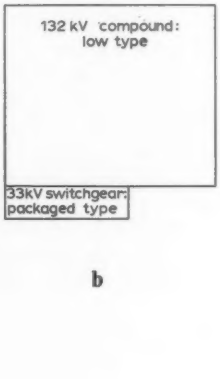
A bulk-supply point established in the 1930's with two 30 MVA step-down transformers could require a high-type substation structure and elaborate buildings for housing the switchgear and the oil-conditioning plant, control room and workshop. This resulted in high capital costs, and it was often felt in those days that the tappings of the 132 kV system could rarely be justified.

A much simpler arrangement is now available for single-breaker open-type 132 kV substations. Four concrete posts carry the overhead connections to a 132 kV circuit-breaker, and two 60 MVA transformers can feed direct onto a 33 kV compact packaged switchboard. This design, while satisfactory from the operation and maintenance points of view, also reduces capital cost, as desired.

Thought is at present being given to providing packaged-type 132 kV switchgear of 3·5 million kVA breaking capacity incorporating draw-out isolating features, thus reducing the civil-engineering work and the space occupied to an absolute minimum. Based on the



a



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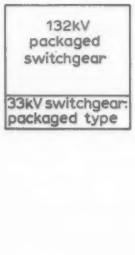
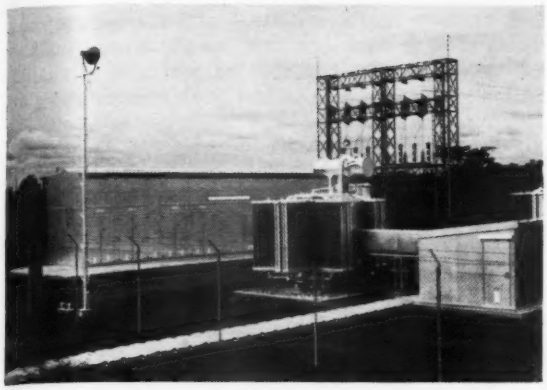


c

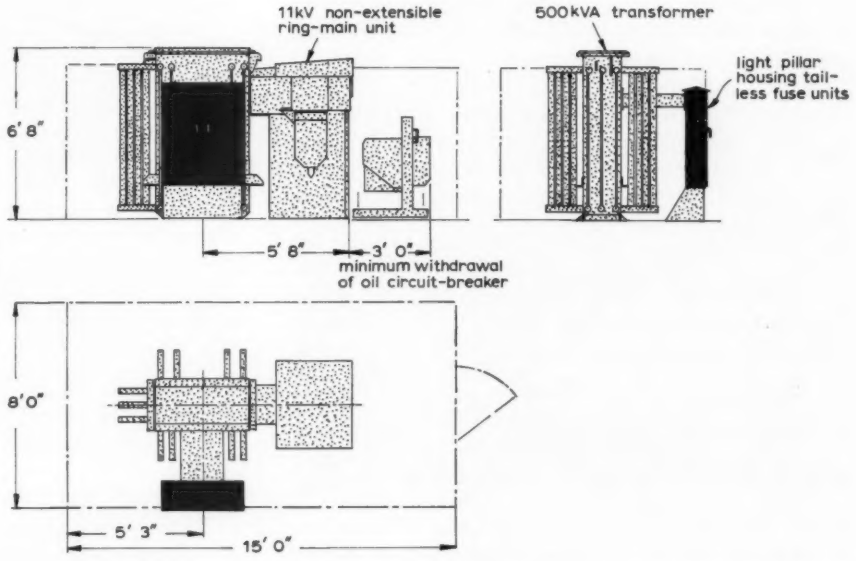
1 *Main bulk-supply substations*

- **a** 5 × 132 kV circuit-breakers
  2 × 30 MVA transformers
  9 × 33 kV circuit-breakers
- **b** 1 × 132 kV circuit-breaker
  2 × 60 MVA transformers
  11 × 33 kV packaged units
- **c** 1 × 132 kV packaged unit
  2 × 60 MVA transformers
  11 × 33 kV packaged units



2 *Packaged-type station incorporating two sections of main 33kV and 11kV switchgear*

present price of plant and civil-engineering work, it is estimated that a 132kV substation built today to the 1930 design would cost about £12 per kVA of firm capacity. Single-breaker substations could reduce this to £4 per kVA of firm capacity.



3 *Possible future arrangement of transformer with bolted-on switchgear and trunking connected to a pillar*

If we can achieve a packaged arrangement for these 132kV substations, not only will the cost per kVA be reduced, but also engineering manpower required for planning, design, manufacture and installation will be more economically used at a time when such skills are at a premium.

The packaged scheme provides a means whereby the maximum can be done in the factory in ideal conditions of manufacturing control, testing and inspection and the minimum left for expensive and difficult installation work at the site. The reduction in the space required for accommodating the plant allows such substations to be installed nearer the load centre, and heavy expenditure in 33kV or lower-voltage copper can be avoided.

Fig. 1 shows the saving in floor space which can be achieved, Fig. 1a being the high-type 132kV bulk-supply point of the 1930's, Fig. 1b the single-breaker bulk-supply point of today, and Fig. 1c the packaged-type substation of the future.

Intermediate distribution

Turning to intermediate (33kV) distribution, we find that, with the main 33kV substations of the 1930's, elaborate buildings were used to accommodate transformers, with complete fire-segregation of the switchgear. The cost of such a substation, if built today, could easily be £15 per kVA of firm capacity.

For step-down substations in built-up areas, the alternative packaged-type 33kV substation forms a very economical arrangement, and for the simpler tapping-points can take the form of ring-main units. For stations of heavier capacity, incorporating two sections of main 33kV and 11kV switchgear, complete packaging can be achieved, as shown in Fig. 2.

For all packaged switchgear, simple foundations accommodate the base frames, and the units are designed to provide cover under which maintenance work can be carried out and also access to the circuit-breakers for operational purposes. Thus the only civil-engineering work necessary is a plain concrete raft with trench work as required. Relay and control features are accessible and combined in the same unit as the main circuit-breaker. Their value for bringing the highest voltage to the nearest point to the load is acknowledged in the American term 'load center' arrangement.

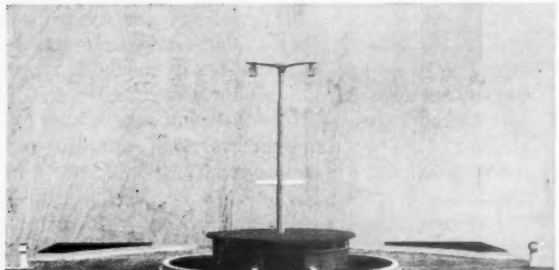
The 33kV packaged substation is already appearing in

this country, and with the use of splayed bushings and air-insulated busbars an isolable circuit-breaker has been provided for use where humidity and pollution have no detrimental effects.

The circuit-breaker is of the vertically isolated type with plug and socket and busbar support arrangement in air. No spout insulation is provided and the insulation in contact with air is of porcelain. The addition of busbar-section isolators, incoming-line isolators and any other extra features required to meet special local conditions can be easily provided as the chambers are simple compartments in which these features can be accommodated in the straightforward manner of building a Meccano model.

The top portions of the switchgear can be simply transported and erected on site. This means that a complete 33kV step-down substation can be engineered in detail in the manufacturer's works and erected on site in a very short time. Should duplicate 33kV busbar switchgear be required, the top parts of the switchboard will accommodate the crossover connections which are required and a simple transfer-breaker arrangement can be adopted.

The 11kV switchgear can, if required, be accommodated in the same housing as the 33kV. This forms a very compact scheme, reducing the site work associated with multicore-cable runs to a minimum and also reducing the length of interconnecting cable required. Similarly, all control features can be accommodated in the run of the 33kV switchgear, so that multicore cables can be run and terminated in the factory. The rapid reconnection of multicores and the reduction of site erection



4 *Substation on traffic island*

time will be appreciated by all distribution construction engineers.

These methods should give to the distribution engineer an excellent 33/11kV tapping-point substation, occupying one-tenth of the space of the conventional open-type arrangement.

Small substations

Finally, there are the thousands of small substations—which are becoming more and more numerous—needed to interconnect the h.v. and m.v. distribution systems. Not only are they needed to feed ever-expanding m.v. distribution networks on new housing estates, but they are also required to reinforce many existing m.v. distribution networks, where satisfactory site accommodation is so often lacking.

The cost of providing copper and excavation and reinstatement on m.v. distribution forms a very high proportion of the cost of reinforcement, and the movement of a substation away from the load centre can result in heavily increased capital charges. Engineers on both the manufacturing and the supply sides are therefore giving considerable attention to methods for simplifying the installation of such substations and reducing their capital cost.

Thirty years ago, brick-built structures were invariably used to house them, but the accommodation of such structures is becoming more and more difficult if they have to be correctly sited to ensure an economical lay-out for distribution purposes.

Much thought has been given to the methods which can be adopted to provide an economical substation in a position which will meet the local amenities, and this has led to the use of simple outdoor substations. Based on present-day costs, substations of the old brick-built design could cost five times as much as the modern outdoor equivalent.

There is much to be said for packaged-type arrangements where transformers can be provided with bolted-on switchgear with trunking to feed a medium-voltage pillar, and Fig. 3 shows a design for the future.

There will still be a need for the larger 11kV distribution substations, which at the moment are generally accommodated in brick buildings. Packaged 11kV switchgear is available which can house all protective equipment, batteries, etc. and allow maintenance work to be carried out under cover.

Even with all these facilities, site restrictions still tend to dictate the type of substation which can be accommodated, and unfortunately many supply engineers are finding that they are being forced to look underground for substation accommodation and there have been many cases where equipment has had to be installed in basements and underground chambers.

Problems of the future

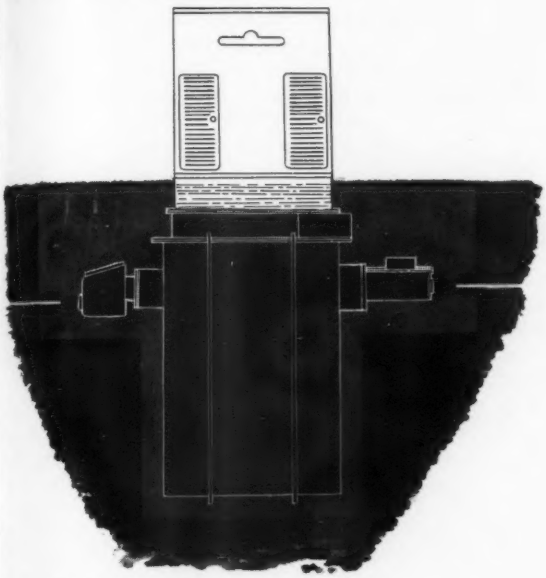
What, however, are we to do in the future? Could transformers and associated switchgear be installed above ground, say on traffic islands, as shown in Fig. 4, or between factory buildings on steel structures, or have we to resort to buried-type transformers to drop direct into the ground (Fig. 5)?

Are we to look upwards as the Americans do, placing their transformers and associated h.v. and l.v. switchgear overhead, or are we to go below ground, requiring the design of special transformers and equipment?

The advent of the pole-mounted transformer has given an economical and simple form of substation for use in all rural districts, and tens of thousands have been installed with very little site difficulty.

The development schemes of our cities give opportunity for substations to be incorporated in all new buildings, and this is possibly the only method of meeting the substation requirements in city areas.

The reliability of electrical distribution plant has meant that greater simplicity can now be incorporated in substation design, and possibly in the future the simple 500kVA distribution substation with ring-main switchgear will be standard practice all over the country for city and urban areas alike.



5 *Buried-type transformer*

Thirty years ago, there were two main lines of thought on substation procedure. Some undertakings provided simple small substations as frequently as possible, and these were often installed in the cellars of the larger houses, receiving a supply from a 2 or 3kV single-phase system using air-cooled transformers. Others had a smaller number of large substations radiating supplies over long distribution distances.

During the intervening years, both systems have undergone changes, and today the areas which differed considerably 30 years ago in distribution practice are very similar. If we look forward to the next 30 years, however, it might well be that substations will again appear in individual premises, and thus we will have had completed a full cycle of change in substation practice.

Summary

The problems of the future can be summarized as follows:

1. The high cost of copper dictates that all loads be connected to the highest possible voltage at the nearest possible point
2. The simplification in the design of main bulk-supply substations has enabled the 132kV system to be economically used for distribution purposes
3. Avoidance, wherever possible, of buildings and expensive site works in substation designs should considerably reduce the cost per kVA of substations
4. More emphasis has been placed in recent years on the efficient planning and operation of distribution systems
5. The use of thermal ratings in cyclic loading conditions has increased the firm capacity of distribution plant
6. The after-diversity maximum demand for domestic consumers has increased at least 20 times over the last 30 years.

The advent of packaged-type switchgear, the combining of switchgear and transformer plant in one unit, and the provision of underground transformers are possibly the most important events which are occurring at the moment and will do much to relieve the problems of the supply engineer of the future in obtaining efficiently sited substations to meet the ever-increasing demand for electrical energy.

Uganda Electricity Board scholarship scheme

UNDER a new scheme sponsored by the Uganda Electricity Board, Uganda students entering the engineering faculty of the Royal Technical College, Nairobi, Kenya, in September 1960 will have the chance of pursuing electrical engineering studies in the United Kingdom after their local training.

Candidates accepted for the 1960–61 courses at Nairobi who state their intention of specializing in electrical engineering after completing the Engineering Institutions Part I Examination are invited to take a few months' employment with the Board before the September 1960 term starts. During this period, at the Board's Njeru training centre, their capabilities will be assessed and suitable students offered vacation employment with the Board.

On successful completion of their courses at the Royal Technical College, selected students will then be eligible for a U.E.B. scholarship to pursue graduate training with a manufacturing firm in the United Kingdom. Candidates will thus be given the opportunity of meeting the training requirements for Corporate membership of The Institution. The scheme will also enable successful graduates to return to Uganda as junior engineers with the Uganda Electricity Board.

Previous attempts to find suitable candidates for engineering scholarships have met with little success, owing to the lack of students with the necessary practical and academic background. It is now hoped to overcome this difficulty by affording further training to suitably qualified students who have demonstrated their practical aptitude in spells of vacation employment with the Board.

The proposal will supplement the Board's existing scholarship and graduate-apprenticeship schemes, under which locally born graduates are already following courses of training accepted by The Institution.

Radio-isotopes and γ-irradiation

Over the last ten years the annual number of consignments of radioactive isotopes, 'labelled' compounds and radiation sources sold by the United Kingdom Atomic Energy Authority for civil purposes has increased from 3500 to 35000. The Radiochemical Centre at Amersham was reconstituted in 1959 to take over the full responsibility of producing and marketing these materials.

From 1949 the Centre had shared with the Isotope Division of the A.E.R.E., Harwell, both the commercial arrangements and the research into possible applications of isotopes. In 1956 a laboratory site for the Isotope Division was developed at Wantage, and gradually the groups from Harwell which were engaged on radio-isotope research have moved to the Wantage Radiation Laboratory, leaving only a small nucleus at Harwell to carry out special irradiations and research directly connected with reactors. These groups—chemistry, physics, technological irradiation and technical, together with the Isotope School, now make up the Isotope Research Division.

The Radiochemical Centre comprises four production departments—inorganic, isotope production unit, natural radio-elements and organic—with a staff of about 300 at Amersham and 50 at Harwell. Ninety-seven 'primary' radio-isotopes are extracted in simple chemical form from materials irradiated in reactors or cyclotrons, from uranium-fission products, or from natural radioactive elements. From these, compounds are derived by chemical synthesis or biochemical techniques so that the resulting substance is 'labelled' by the radiation of the radio-isotope and can be traced through subsequent industrial, medical or other processes. For example, over 200 labelled compounds of carbon 14 have been synthesized, including amino acids, steroids, etc.

A wide range of radiation sources containing α, β or γ emitters is manufactured from the natural radio-elements and from artificial radio-isotopes, chiefly for use in radiography, industrial and medical, and in radiotherapy.

The Isotope Research Division at Wantage is responsible for research into the preparation and use of radio-isotopes, including improved chemical-preparation techniques, instruments for industry, applications to studies of flow, soil depth, coastal erosion, etc., and potential uses of the large amounts of radioactive materials becoming available from the nuclear power programme, the last being the particular concern of the technological irradiation group.

Medical applications of radio-isotopes

Many of the consignments sent to all parts of the world from Amersham are directed to hospitals and medical research institutions, where the value of radio-isotopes in therapy, diagnosis and tracer studies of vital processes is already widely acknowledged. The technological irradiation group at Wantage is meanwhile studying the sterilization by γ-irradiation of pharmaceutical and surgical products.

For example, to prevent cross-infection, disposable gloves, syringes, etc. can be made of plastic which will not, however, tolerate heat sterilization. Sutures are already being sterilized by irradiation in the United States on a commercial scale. Other medical equipment can be packed in polythene after normal handling and subsequently irradiated to obtain the necessary purity. Many of the pharmaceutical products dispensed at Amersham are, in fact, sterilized in a similar way.

Since ionizing radiation will kill bacteria, yeasts, moulds and insects without an appreciable rise in temperature, the effects of radiation on the quality, wholesomeness and nutritional value of several food items have been studied. Meat was preserved satisfactorily by a dose of 5 Mrad, provided that it was subsequently kept in a refrigerator to prevent the multiplication of the surviving 1 or 2% of bacteria. *Salmonella* in frozen eggs could be treated by irradiation in the frozen state. Fruit preserved remarkably well, and its 'shelf-life' could be doubled or trebled; milk acquired an unpleasant taste.

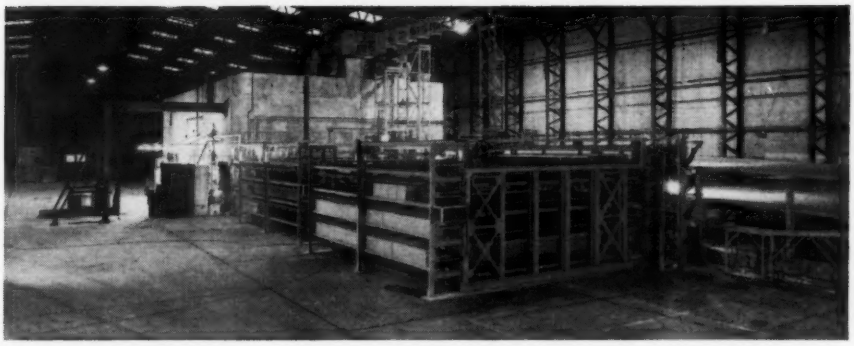
Package-irradiation plant

For samples to be irradiated weighing less than 1 cwt, 23 experimental cells, each containing 100–10000 curies of cobalt 60—ranging from point sources to clusters of 3 ft articulated rods—are available at Wantage for internal research and for occasional use by industry (see Fig. 1).

When small-scale experiments have shown the feasibility of an irradiation process, confirmation by larger-scale trials is generally required, and a pilot plant for the use of the Authority, and particularly for the convenience of potential industrial users of the technique, has been built at Wantage (Fig. 2). Actual manufacturing trial runs have just started, and orders already received ensure work for at least a year.

The products to be irradiated are packed into standard-sized boxes (14 × 12 × 9 in.), which are automatically

1 *The interior of one of the radiation cells at Wantage*



2 *Package-irradiation plant at Wantage*

conveyed to an irradiation chamber and exposed to radiation from a cobalt 60 source. Initially, this rectangular source, comprising vertical rods of cobalt 60 which have been pile-irradiated for two years, contains 150000 curies. When not in use, it is lowered into an 18 ft-deep pond in the irradiation chamber. The packages are conveyed automatically from the chamber to a storage rack.

Doses in the range 0·01–5 Mrad can be administered, and the capacity of the plant is 100 ft^3 per day at a sterilizing dose of 2·5 Mrad. The cost at this dose is 15s. per cubic foot, but with a special-purpose plant this could be reduced.

Industrial techniques

The use of radio-isotope techniques is estimated to save industry millions of pounds each year, and about 70% of this saving derives from the use of gauges containing radiation sources for measuring thickness, level, depth, etc. Adaptation of radio-isotope techniques to solve practical problems posed by industry, hospitals and other bodies is the chief concern of the physics group at Wantage. For example, long-term stability of transistors in computers and undersea repeaters depends on perfect sealing, and leaks can be detected by immersing components in an atmosphere of krypton 85 at high pressure. The amount of radiation emitted by components on removal gives a quantitative indication of the size of the leak.

Tracer techniques have been developed for studying gas and liquid flow, the efficiency of mixing processes, coastal erosion, and mineral prospecting. The physics group's work by itself indicates the exceptional diversity of use and user which is a notable characteristic of radioactive isotopes.

CENTENARY OF THE R.I.N.A.

A note from Sir Hamish MacLaren

I HAD the privilege of representing the President of our Institution at the centenary celebrations of the Royal Institution of Naval Architects, which were held from Monday, 16th May to Friday, 20th May 1960.

On the Tuesday, after an excellent buffet lunch, the proceedings at the Royal Festival Hall, London S.E.1, were opened by the Duke of Edinburgh, who in his inimitable style complimented the R.I.N.A. on their progress and wished them well for the future. He was replied to by the President of the R.I.N.A., Lord Runciman of Doxford. We then heard two papers, the first by Mr. A. J. Sims, Director General of Ships (Admiralty), on 'Warships 1860–1960', and the second by Mr. J. M. Murray, Chief Surveyor, Lloyds Register of Shipping, on 'Merchant ships 1860–1960'.

We were entertained on Tuesday evening by H.M. Government at a cocktail party at Lancaster House, where we were received by the First Lord of the Admiralty, Lord Carrington, and Lady Carrington. This was followed by a dinner at Claridge's for the official guests and delegates of other institutions from the Commonwealth and elsewhere.

On the Wednesday the members and their ladies and guests went by river from Westminster to the Royal Naval College, Greenwich, where the College and the Maritime Museum were on view. At 9.30 on Wednesday evening we were given supper in the Guildhall by the Lord Mayor and Sheriffs of the City of London.

Thursday, 19th May was to me and to most the highlight of the celebrations. We were conveyed by special train drawn by 'The Evening Star' to Stratford on Avon. Lunch was provided on the train, and on arrival we attended a matinée performance at the Memorial Theatre of 'Twelfth Night'. The performance was quite outstanding and was made more interesting to us all by the fact that the leading lady, Dorothy Tutin—playing the part of Viola—is the daughter of a member of the R.I.N.A., and Mr. and Mrs. Tutin were present.

We dined on the train on our return journey. My one regret was that I had not been informed in advance that we were to have 'The Evening Star' specially laid on, as otherwise I would have provided myself with a boiler suit and spent part of the journey on the footplate of the last steam locomotive to be built for British Railways.

On the Friday morning we were conveyed by coach to the Hydrodynamics Laboratory at Feltham, where Lord Runciman presented the Laboratory with the R.I.N.A. Gold Medal in acknowledgment of its contribution to the design of ships.

After lunch we were shown round, and after tea we were returned to London in time to change for dinner. A very enjoyable dinner at the Dorchester Hotel concluded the celebrations and four memorable days.

I am most grateful to the President and Council of our Institution for giving me the opportunity to attend these celebrations. Not only did I meet friends in our shipbuilding industry, but I met again many old friends and acquaintances among the delegates of institutions oversea—from Australia, the United States, the Netherlands, Norway and Sweden.

INSTITUTION COUNCIL MEETING ON THE 19th MAY 1960

THE following summary of reports received and decisions reached by the Council of The Institution at their meeting on the 19th May 1960 is issued on the authority of the President in a form approved by the Council. It will be understood that this report does not purport to be a complete account of the matters discussed at the meetings, as some items are to be the subject of further discussion by the Council.

Membership

The Council gave final confirmation to the election and transfer of those candidates whose names had been published with the April 1960 *Journal*, to become effective from the 1st June 1960. Taking these into account, the total membership at that date would be 46379.

Members outside the area of a local Centre

The General Purposes Committee supported a recommendation providing for the appointment of a panel to study means of bringing all members within the ambit of the local Centre organization. In approving this, the Council asked the General Purposes Committee to arrange for the panel to be set up with an appropriate constitution.

Training Regulations—form XIT

Mr. G. S. C. Lucas, Chairman of the Education and Training Committee, introduced the Committee's proposed amendment to the form XIT for the submission of details of training under the Training Regulations. The Council agreed to the amendments proposed, which provide for a more direct indication of the professional connection between a candidate and the chartered electrical engineer who signs the declaration as supervisor of his training in a staff appointment.

Reception for oversea graduates

The Council accepted a further proposal from the Education and Training Committee that a reception for oversea graduates, to meet the President and members of Council, should be held in September 1960. No similar reception had been held in 1959 owing to the building alterations, but those held in previous years had been much appreciated. The graduates invited include the Athlone Fellows, F.B.I. Scholars and other graduates known to The Institution who are in the United Kingdom for further education or training.

Henry Nimmo Prize

Approval was given to a recommendation of the Examinations Committee that the value of the Henry Nimmo Prize be increased to 20 guineas. This was proposed at the request of Mrs. Nimmo, since the bequest of the late Henry Nimmo was now producing a greater income than had originally been expected.

Council nominations

It was reported that the following nominations had been received in connection with the elections to the Council for 1960, each put forward by ten members as laid down in the Bye-laws, in addition to the nominations made by the Council themselves (see April 1960 *Journal*, p. 252):

MEMBERS

F. B. Allcock, B.SC.TECH.	Director of Navy Works (Electrical and Mechanical), Admiralty, Pinner, Middlesex
J. S. McPetrie, PH.D., D.SC.	Director General of Electronics Research and Development, Ministry of Aviation, London W.C.1
A. R. A. Rendall, O.B.E., PH.D., B.SC.	Head of Designs Department, Engineering Division, British Broadcasting Corporation, Broadcasting House, London W.1
R. L. Smith-Rose, C.B.E., D.SC., PH.D., F.C.G.I.	Director, Radio Research Station, Department of Scientific and Industrial Research, Ditton Park, Slough, Bucks.

ASSOCIATE MEMBER

R. Feinberg, DR.-ING., M.SC.	Visiting Lecturer, Electrical Engineering Department, Manchester College of Science and Technology, Sackville Street, Manchester (on loan from Ferranti Ltd.). Age 56.

Institution Library

The report of the Library and Museum Committee for 1959 showed that there had been a slight fall in the number of readers, which was thought to be due to conditions during the rebuilding operations in the Library. Attention was also called to the decline in the use of the Lending Library, although it was felt that this might have a similar cause.

Proposed Joint Group in Jamaica

The Joint Oversea Activities Committee of the three major engineering institutions had supported a petition which had been received from 73 out of 87 known members of The Institution resident in Jamaica, requesting authority to form a Joint Group. This was approved, and it was noted that The Institution of Mechanical Engineers was to service the new Group.

Extended Joint Groups

Following the approval which had been given at the meeting of the Council held on the 14th February 1960 (see March 1960 *Journal*, p. 155) to a proposal that those Joint Groups who so wished should be authorized to extend their

membership to include members of certain other engineering societies, approval was given to a draft of regulations for such extended Groups, to be promulgated by the Councils of the three institutions, in a form prepared by the Joint Oversea Activities Committee.

Co-operation with the Engineering Institute of Canada

A third recommendation from the Joint Oversea Activities Committee dealt with a proposed basis for co-operation between the Engineering Institute of Canada and members of the three home institutions resident in Canada. This had been formulated as a result of an examination of this problem by the Council of the E.I.C., who had ratified a series of measures designed to develop, within the branches of the E.I.C., greater co-operation with and facilities for members of other Commonwealth institutions resident in Canada.

The Council approved the proposal as a welcome solution to a long-standing problem, and stressed that, for the new arrangement to be effective, every means should be employed to make the improved facilities known to every member of the home institutions resident in Canada. The Commonwealth Conference would discuss, at a later stage, the possible extension of the scheme to all the Commonwealth institutions.

Subscriptions

The Council received a report from the Finance Committee of members whose subscriptions were more than two years in arrear at the 1st April 1960. The list contained 343 names, against 348 last year, and represented 0·77% (0·78% last year) of the membership. The Council approved the Committee's recommendation that a final notice under registered cover be sent to these members, and that the names of those from whom there was no reply be removed from the register of members under the provisions of Bye-law 37.

MEDICAL ELECTRONICS CONFERENCE

THE Third International Conference on Medical Electronics has been designed to appeal not only to specialists but also to those in the medical and electrical engineering professions who wish to learn more about the background of the techniques used in this rapidly expanding field. Brief notes on a few of the subjects to be covered at the conference will indicate the versatility of electronics in its application to physiological research and to medicine.

Discussion of the physical and electrical effects of microwave radiation on living organisms, particularly on the eye, will have special topicality, and suggested designs for radiation-intensity monitors are to be put forward. Several papers will deal with the use of ultrasonics in medical diagnosis and in ophthalmology, and a film of intercellular movement in plants caused by ultrasonic excitation of cell walls is to be presented.

Much research is being carried out on the measurement and analysis of biopotentials; results to be given include some from the Soviet Union. A new form of e.e.g. display has been developed to aid the study of problems of anaesthesia, which could be constructed, the author indicates, from equipment to be found in any research laboratory. Papers will be presented on the analysis of heart murmurs, and the monitoring of foetal heart-beats. A tiny self-contained cardiotachometer for continuous measurement, which can be carried by the patient at all times with no inconvenience, will be described by its designer.

Electronic control in medicine covers muscle, reflex-arc and neural stimulation, anaesthesia control and control of glandular functions. There will be a paper surveying these applications. Instruments will be described which measure blood flow, air flow in the lungs, strains in respiratory muscles, the mixture of respiratory gases, etc.

Computers, analogue and digital, have contributed much to biomedical research, and the author of a paper reviewing their uses suggests that a computer unit should be part of every medical centre. Other subjects to be discussed include the applications of an ultraviolet colour-translating television microscope, an aid for blind telephone operators, and telemetering problems in space flight.

New B.B.C. stations

THE second stage of the B.B.C.'s scheme to extend the coverage and improve reception of its television and v.h.f. sound broadcasting services by means of satellite stations has been approved in principle by the Postmaster General.

The towns and districts to be covered in this stage are: Forfar, Angus, Grantown on Spey, Lewis, Pitlochry/Aberfeldy, Shetland and Skye (television and v.h.f. sound); Caernarvon, Hastings, Scarborough and Swindon (television); and East Lincolnshire, Enniskillen, Pembroke/Milford Haven, Sheffield and South-West Scotland (v.h.f. sound). Television stations are being provided for Enniskillen, Pembroke/Milford Haven and Sheffield by the first stage of the plan.

Some stations will cover only the towns where they are to be built, but others, especially Caernarvon and Forfar, will have a somewhat wider service area. Most of the stations will use translators, which receive programmes by direct reception from an existing station and relay them on another channel for local viewers and listeners. The television station at Hastings is to use a new type of low-power translator, the 'parent' station being Crystal Palace.

The 23 B.B.C. television stations cover 98·8% of the population; a further 200000 people will benefit from stage 1 and 100000 from stage 2. The coverage of the 20 existing v.h.f. stations, serving 97·3% of the population, will extend to another 90000 in stage 1 and 350000 in stage 2. In addition, reception will be improved in many areas.

Completion of stage 2 is expected by March 1964, possibly earlier. Tentative plans are being considered for many additional translator stations, for television and v.h.f. sound, in areas that will still be without a satisfactory service.

An early electric cell? 621.352

Shortly before the Second World War a clay vessel containing copper and iron 'electrodes' was excavated near Baghdad. An Austrian who was present suggested, in a book published in 1940, that it was an electrical element and, further, that similar elements were used in galvanic gold-plating 4500 years ago. The subject was recently revived in an article in a German technical publication, and the following note was prepared, after further investigation, by Mr. C. MacKechnie Jarvis, Member.

DURING the past few years, several articles have appeared in the German technical Press on the subject of a reputed electric cell, claimed to have been excavated on a site presumed on archaeological evidence to date from the period between 300 B.C. and A.D. 300.

The matter has again come into prominence through an article in the publication *Elektrie** by Dr. H. Winkler, which refers to other German publications not readily available in this country, and restates the evidence.

The find

According to Dr. Winkler, the story begins with excavations in Iraq on a site at Khujut Rabuah, in the neighbourhood of Baghdad, around 1936. It appears that one of those present was Wilhelm König, according to whom the remains investigated belonged to the Parthian Empire. König published a book† in 1940, in which he described his work in Iraq, and from which Dr. Winkler quotes as follows:

'Something rather peculiar was found and, after it had passed through several hands, it was brought to me. A vase-like vessel of light yellow clay, whose neck had been removed, contained a copper cylinder which was held firmly by asphalt. The vase was about 15 cm high; the sheet-copper cylindrical tube with bottom had a diameter of 26 mm and was 9 cm long. In it, held by a kind of stopper of asphalt, was a completely oxidized iron rod, the top of which projected about 1 cm above the stopper and was covered by a yellowish-grey, fully-oxidized thin coating of a metal which looked like lead. The bottom end of the iron rod did not extend right to the bottom of the cylinder, on which was a layer of asphalt about 3 mm deep. The question as to what this rare find was received the most surprising answer, after all the parts had been brought together and then examined in their separate parts. It could only have been an electrical element. It was only necessary to add an acid or an alkaline liquid to complete the element.'

Dr. Winkler continues:

'König also conjectured that galvanic gold-plating had been carried out with these or similar elements as early as 2500 B.C. In 1937 there were also ten elements from Seleucia in the Berlin Museum. . . . All these finds have probably afforded proof that "flowing" electricity, which after Galvani is called galvanic electricity, was known in the dim past, that is long before he appeared on the scene.'

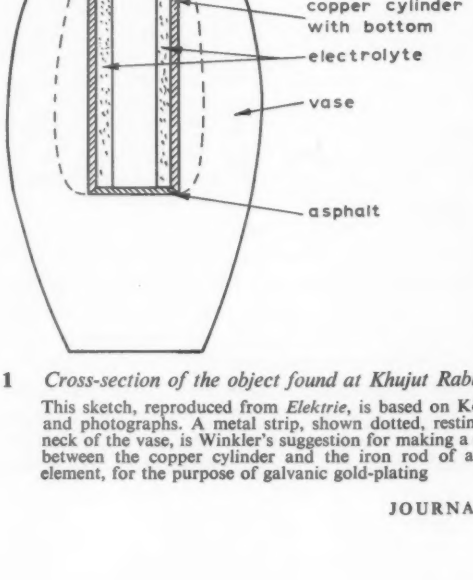
As König's book was published during the Second World War, the reference to the electric cell seems to have passed unnoticed. The attribution to the Parthian era is, however, startling and prima facie somewhat suspect. It poses a number of questions, the answers to which will demand a not inconsiderable amount of investigation.

König's description is that of a relatively sophisticated electric cell. He refers to a copper cylinder which, in an illustration (see Fig. 1) in Winkler's article purporting to have been taken from König's book, appears to be intact, and there is nothing in König's description to the contrary. On the other hand, the top of a completely oxidized iron rod 'was covered by a yellowish-grey, fully-oxidized thin coating of a metal which looked like lead'.

This somewhat conflicting statement demands an explanation for the apparent survival of the copper and the decay of the lead. Is it possible that 'the fully-oxidized thin coating of a metal which looked like lead'(!) was, in fact, a compound of tin? If this proved to be the case, the similarity between the construction of the ancient and modern would be even more remarkable.

Evidence of galvanic gold-plating?

König, we are told, was of the opinion that galvanic gold-plating had been carried out not only at this period but as early as 2500 B.C., and it is pertinent to ask, first, whether any evidence exists that the process was in fact employed and, further, whether there are grounds for the slightest justification of the much broader claim to phenomenal antiquity.



1 *Cross-section of the object found at Khujut Rabuah*

This sketch, reproduced from *Elektrie*, is based on König's data and photographs. A metal strip, shown dotted, resting over the neck of the vase, is Winkler's suggestion for making a connection between the copper cylinder and the iron rod of an adjacent element, for the purpose of galvanic gold-plating

* WINKLER, H.: 'Galvani und Volta nur Wiederentdecker—eine dringend notwendige Berichtigung', *Elektrie*, 1960, **14**, no. 2, p. 71
† KÖNIG, W. 'Im verlorenen Paradies' (Baden bei Wien, 1940)

It would be interesting to know if the operation of gold-plating can be performed in a satisfactory manner from a gold electrode using an electrolyte likely to have been available at a time when there was probably no known solvent for gold, and hence no known gold salt.

Perhaps in the minds of those familiar with early electrical history an even greater difficulty in accepting the conclusions reached in Germany lies in the implication of the relatively high standard of technological development inferred.

Is it reasonable to expect that experimental science having led to the discovery of electroplating, subsequently practised for over 2000 years (necessarily in a number of distinct civilizations), would not have prompted further experiment with multiple cells, which must sooner or later have resulted in the discovery of the electric spark, and other characteristic effects?

In a great many cases the discovery of one ancient people spreads to others by contact and by exchange, and this is, of course, inferred in König's statement. From whom, for example, would the Parthians have obtained the secret if it were not from some earlier Semitic race? Could the Assyrians or Babylonians have possessed the information for a long period without disclosing it in exchange for other information to Egypt, with whom there was at different periods considerable intercourse? We know a great deal about the Egyptians for centuries prior to the Greek occupation, and it would indeed be interesting to know if there is anything in the surviving literature remotely implying the knowledge of electrical processes in any form.

Alternative explanations

It is pertinent at this stage to consider whether there is any alternative explanation for the object found by König, and the following suggestion is made without the opportunity for visual examination of the find. It is that the object found is a cell of modern origin and that its presence in the desert in the neighbourhood of Baghdad can be explained by the activity of telegraph enterprise during the second half of the 19th century, when overland telegraphs were erected by the pioneer companies. Alternatively, it is possibly more recent and may be attributed to the desert campaign in Mesopotamia during the 1914–18 War.

It is fair to say that Dr. Winkler's illustration indicates the cell enclosed in a substantial vase-like pot, admittedly of a somewhat unusual shape. Could this have been a product of a local pottery to replace breakages of the more conventional type of container?

The subject is fascinating, and it may well be that members will have views to express on some of the issues raised.

THE INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY

The incorporation of a new body on the 17th May 1960, under the name of The Institute of Physics and The Physical Society, marks the fulfilment of the desire expressed by the overwhelming majority of the members of the Institute and the Society that the necessary action should be taken to implement the scheme for amalgamation prepared by a joint committee. The originating bodies will shortly be formally wound up and their assets handed over to the new one.

The first President of the amalgamated body is Sir John Cockcroft, and the four Vice-Presidents are Dr. J. Topping, Dr. W. H. Taylor, Prof. R. W. Ditchburn and Mr. A. J. Philpot, each responsible to the Council for a defined area of the many activities to be taken over by the new organization from its predecessors. The Presidents of the predecessors (Sir George Thomson and Mr. J. A. Ratcliffe) are also members of the new Council. The other officers are Dr. J. Taylor (Hon. Treasurer) and Dr. C. G. Wynne (Hon. Secretary).

The Physical Society of London, as it was then called, was founded in 1874, and on the initiative of that Society's Council The Institute of Physics was founded 45 years later. The original scheme envisaged a kind of federation of societies interested in physics, to provide, among other objects, rooms for meetings, a library, and a common secretariat. In fact, the Institute's offices were in the Society's present rooms in South Kensington from 1927 to 1949, and the Institute provided the secretariat for The Physical Society and The Optical Society, which themselves amalgamated in 1931.

At the time of its establishment, no one could have foreseen the great growth and influence of physics in the modern world. Broadly speaking, before the Second World War the scientific meetings and publications of the Institute dealt with applied physics, while those of the Society were concerned more with pure physics. As, however, the boundary between these two aspects became less definite, there was increasing overlap in the activities of the two bodies and in their membership. It is not surprising, therefore, that during the past 20 years proposals for the amalgamation of the two bodies have been made repeatedly and from time to time detailed proposals examined, until eventually a satisfactory solution was worked out.

The qualifications for the awards of Fellow of The Institute of Physics, Associate of The Institute of Physics, and Graduate of The Institute of Physics will remain unchanged, and members of the new body holding these diplomas will also be Fellows of The Physical Society. Besides the three Institute of Physics' grades of membership of the new body, there will also be the grade to be known as Fellow of The Physical Society. All the Fellows of the old Society will be automatically transferred to this new grade, but new candidates for election to the grade will be required to possess a degree or diploma in physics recognized by the Council, or to satisfy the Council that they have a sufficient knowledge of physics.

Provision has been made for other scientists and engineers to participate in the scientific and educational work of the new body. Activities relating to the practice of the profession as such, will be strictly confined to those possessing one of the Institute's diplomas.

The executive officers of the new body are Secretary, Dr. H. R. Lang; Editor and Deputy Secretary, Dr. A. C. Stickland; and Deputy Secretary, Mr. N. Clarke. The registered offices and headquarters are at 47 Belgrave Square, London S.W.1, and, for the present, offices will also be retained at 1 Lowther Gardens, South Kensington, London S.W.7.

Linear induction motors for conveyor drives

A brief account of a Utilization Section paper (3225) entitled 'The application of linear induction motors to conveyors' by E. R. Laithwaite, M.Sc., Ph.D., Associate Member, D. Tipping, B.Sc., and D. E. Hesmondhalgh, M.Sc. The paper is published this month in Part A of the Proceedings. Dr. Laithwaite and Mr. Tipping are in the Electrical Engineering Department, University of Manchester, and Mr. Hesmondhalgh is in the Electrical Engineering Department, Queen's University, Belfast.*

RECENT developments in linear induction motors have suggested that they might be applied with advantage to the driving of certain types of conveyor. In particular, coal conveyors, which are normally operated through rollers driven by conventional induction motors, have the disadvantage that the force is applied to the belt over a comparatively small area so that the force per unit area is large. This is liable to stretch the belt and, if stretching occurs, slipping may result so that some of the drive is lost, excessive wear takes place, and the possibility of fire arises.

Conditions of working may range from very dry and dusty to very wet and slimy, and it is difficult to make roller-driven conveyors operate satisfactorily in all conditions of load. If, for example, the power is applied to the belt at more than one point, the driving units are effectively interconnected only by means of the belt, which is elastic. Hunting, unequal loading and excessive slip are almost certain to occur.

Independent of friction

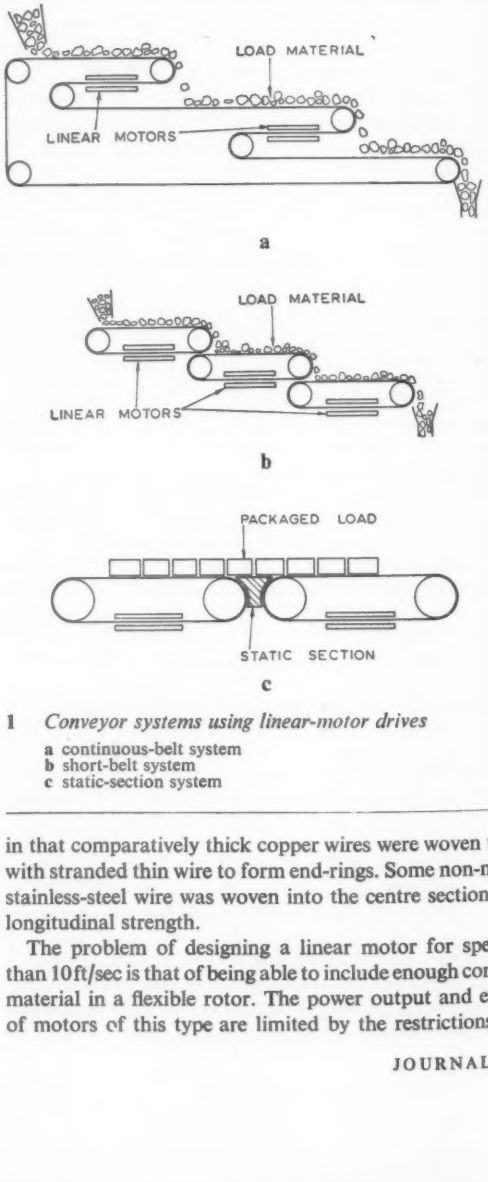
The proposal to utilize linear induction motors involves the use of a belt of conducting material which passes between a pair of linear stator blocks carrying a polyphase system of coils, connected so as to drive a travelling magnetic field through the belt, the latter constituting the 'rotor' of the induction machine. Such a system will exert a uniformly distributed force over a large area of belt without mechanical contact. The drive is therefore independent of the coefficient of friction.

There are many types of conveyor system, ranging from coal transporters and production-line belts to passenger conveyors such as escalators and lifts, but most types have one feature in common in that the linear speed rarely exceeds 10ft/sec. Generally the conveyor takes the form of an endless belt, with only a portion carrying the load and the remainder used as return path. The proposal to use linear motors as the driving mechanism demands that the drive shall take place over sections of the belt which are not carrying goods, so that the belt can pass between the stators with the minimum clearance.

Fig. 1a illustrates how double-sided linear motors may be included in the active side of a conveyor system provided that the goods can be dropped through a small distance. Fig. 1b shows an alternative system which is more economical as regards total length of belt. This system can be developed for use with goods which cannot be dropped, by the use of small fixed regions as shown in Fig. 1c.

Woven-wire belts

Two forms of flexible belt have been tested in a linear motor. The first consisted of woven copper wire as shown in Fig. 2. An attempt was made to simulate a squirrel-cage rotor in that comparatively thick copper wires were woven together with stranded thin wire to form end-rings. Some non-magnetic stainless-steel wire was woven into the centre section to give longitudinal strength.



1 *Conveyor systems using linear-motor drives*
a continuous-belt system
b short-belt system
c static-section system

The problem of designing a linear motor for speeds less than 10ft/sec is that of being able to include enough conducting material in a flexible rotor. The power output and efficiency of motors of this type are limited by the restrictions on the

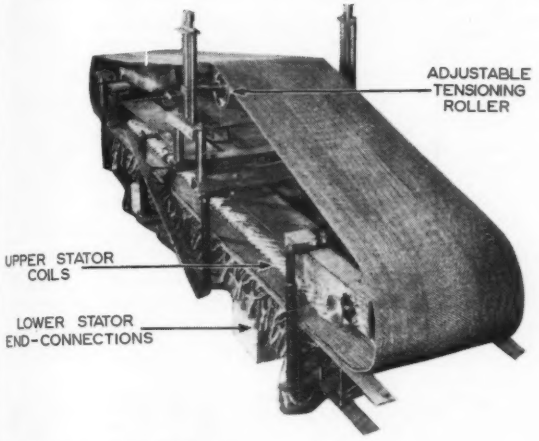
* This article and those following are based on, and written by the authors of, current Institution papers. The authors have been asked to make these articles so far as possible interesting and of appeal to electrical engineers who have no specialized knowledge of the topics, and the content of the articles is not necessarily confined to the subject-matter of the original papers

electric and magnetic circuits thereby imposed. Driving from a 50c/s supply is uneconomical. The experimental machine shown in Fig. 2, which had stators 6in. wide and 10ft long, gave an efficiency of 23% at 7·5ft/sec when fed from a 12c/s supply.

Effective end-turn resistance was investigated, and it was shown that the efficiency could have been raised considerably by better design. The properties of a larger machine were then predicted. A 36in.-wide belt of copper bars ¼in. thick should be capable of delivering 10h.p. per foot of stator length at 61% over-all efficiency at 7·5ft/sec when supplied at 5c/s.

Plate conveyors

The second type of machine investigated is shown in Fig. 3.



2 *Woven-copper-wire belt*

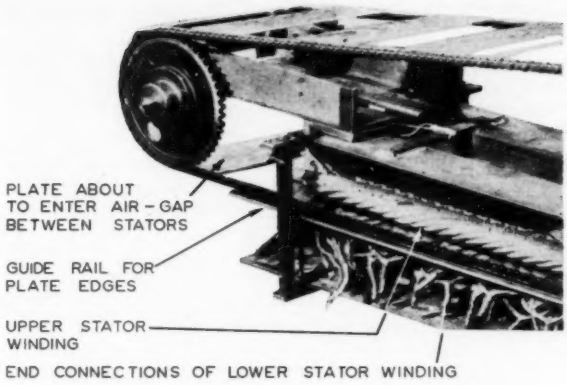


PLATE ABOUT TO ENTER AIR-GAP BETWEEN STATORS
GUIDE RAIL FOR PLATE EDGES
UPPER STATOR WINDING
END CONNECTIONS OF LOWER STATOR WINDING

3 *Experimental plate conveyor*

The belt is made from aluminium plates bolted to chains which run along each side of the track. Although the conductivity of the plate material is much greater than that of a woven belt of equal thickness, the effective resistance of the plate belt is greater than the resistance of a continuous sheet owing to the discontinuities demanded by the flexibility.

A detailed investigation of this 'short-rotor' effect was carried out and plate conveyors were found to be capable of delivering about 1·5 times the power output of the equivalent woven-belt conveyor at a higher efficiency, provided that the plates were not reduced below a pole pitch in length. An over-all efficiency of 43% was achieved with the experimental machine shown in Fig. 3 using the same stator as that in Fig. 2. For a 36in.-wide machine the predicted efficiency is 75%.

621.313.333:621.34

Induction generators

A brief article based on a Supply Section paper (3140) entitled 'Water-turbine-driven induction generators' by C. L. C. Allan. The paper was published individually in December 1959 and will be republished in Part A of the Proceedings. It was read before the Supply Section on the 13th April 1960 at Savoy Place (see p. 388). The author is with the North of Scotland Hydro-Electric Board.

An induction generator has no excitation system of its own and when connected to an electricity-supply scheme draws excitation current from the network to which it delivers power when driven above synchronous speed by a prime mover.

The principle of such generators has been understood for many years. Their most useful application is probably to water-power developments and by far the majority in this country have been employed since the Second World War in hydroelectric stations in the North of Scotland. While most schemes are small some up to 5MW are successfully in use and in suitable circumstances even larger ones could possibly be employed.

The numerous different machines and stations in the North of Scotland vary from small sets of 30–500kW passing compensation-water flows from dams to conventional hydro-electric systems with machines of 4–5MW. Fig. 1 is a cross-sectional view of the Mullardoch Dam 2·4MW installation through which water passes from Mullardoch Reservoir to Loch Benevean which in turn feeds a main 66MW generating station at Fasnakyle. Fig. 2 is a photograph of Sron Mor power station.

Wide application

There is however quite a wide range of employment in other parts of the country. For example waste heat at an acid-production plant is used for raising steam to power a turbo-generator unit having an induction machine connected to the substation which supplies the acid plant with power from the mains. In another application high-pressure water required in an industrial process is released through a small water turbine driving an induction generator and so energy is recovered which would otherwise be wasted. Indeed there are opportunities for energy recovery from many small power

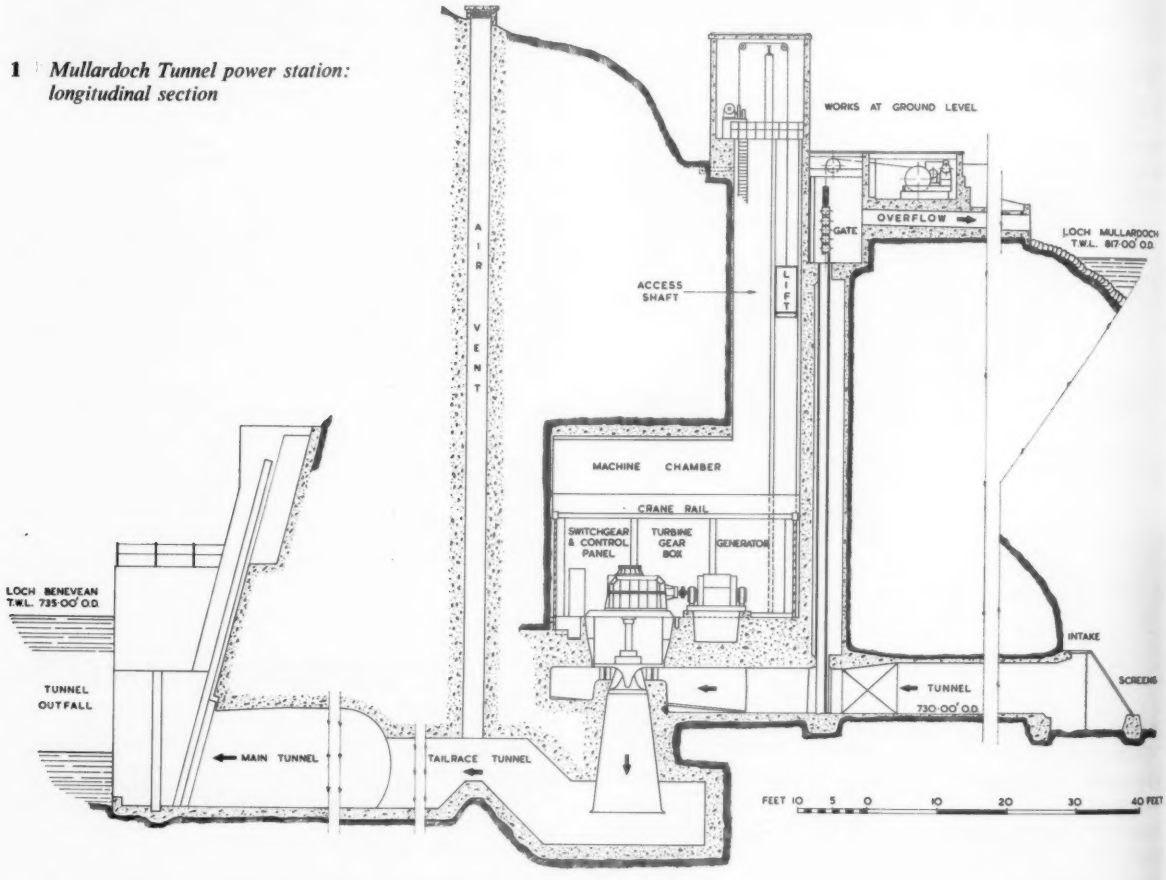
sources where a simple and reduced installation at low cost is required.

There are also in several parts of the country small hydroelectric schemes which originally used d.c. generators. When these required replacement because of changeover to alternating current the lower cost and the simplicity of an induction generator compared with a synchronous machine influenced the provision of the former and allowed an extended useful life to be obtained from the system.

and good power factor. An induction generator can however be designed to have suitable characteristics at its normal speed since it is started by its own prime mover and problems of starting against load and starting-current do not arise.

It is usual practice in designing any hydroelectric machine to allow a factor of safety at the turbine runaway speed, perhaps 75% overspeed. Usually overspeed does not need to be taken into account with a motor which is always

1 *Mullardoch Tunnel power station: longitudinal section*



Data about the amount of installation in other countries would be interesting: there are certainly some noteworthy schemes in the United States and reference has been made to a station with twelve 1·2MW sets.

Design features

While any induction motor would function as a generator if it could be driven above synchronous speed a machine designed for generating only can be arranged most suitably by paying attention to certain features. Motor design has to take into account the requirements of good starting torque and low starting current. The rotor-design features required to achieve these results tend to militate against high efficiency

running below synchronous speed. With hydroelectric installations the overspeed requirement may lead to a lengthening of the rotor in order to keep the diameter small.

Excitation

When a small machine is connected to a relatively large network the effect of its lagging magnetizing current on the system can be ignored, but if the total quantity of induction-generator plant in the scheme is significant it is necessary to be clear whether the excitation current is being supplied advantageously and at no cost since this would affect the economics of the installation.

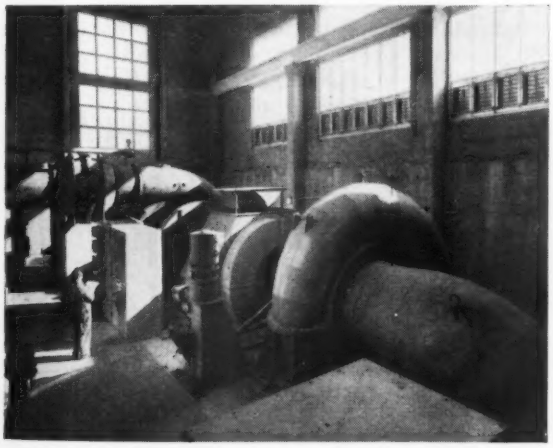
In the system in the North of Scotland described in the paper the additional reactive load of the induction generators tends to be advantageous.

Control and operation

A prime mover driving an induction generator does not require a synchronous governor. Electrical output is determined by the mechanical input to the generator shaft and the machine runs at a speed above synchronous, so exporting power to the main electrical scheme. There is no rigid synchronous electrical tie to the network and a speed governor is unnecessary. Since machine magnetization is supplied externally and the voltage is determined mainly by the supply system and only to a secondary degree by the induction-generator load, no voltage-control arrangements are required.

Compared with a small synchronous alternator which requires an excitation arrangement and voltage-control equipment, significant cost reductions in small plants are possible. It is also worth noting that induction generators provide no complication or dangers from possible back-feeds to supply mains which would otherwise require special precautions.

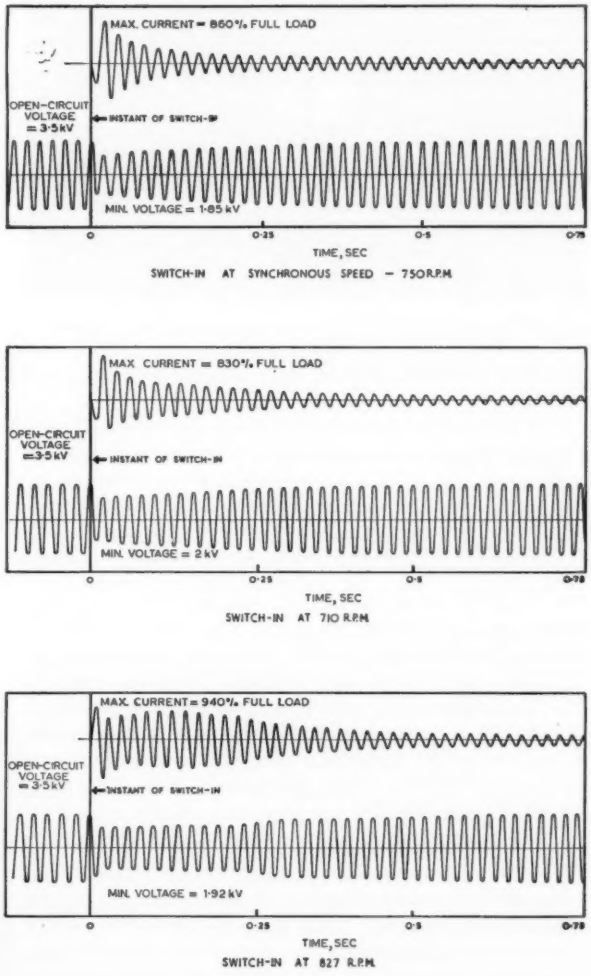
A number of control arrangements require consideration in planning an installation and its electrical and mechanical protection. Some particular factors have to be observed in connection with switching-in, possible excitation from system capacitance and other operational matters, as well as special features arising during commissioning. Details of these are given in the paper.



2 *Sron Mor power station*
5MW turbine and pump with induction machine

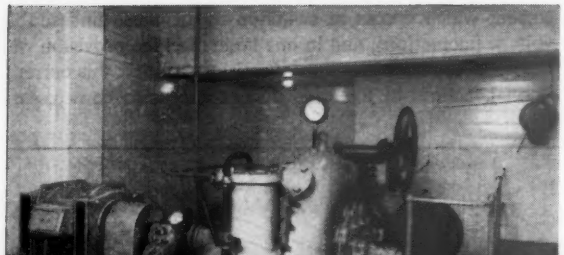
Operating experience

No particular difficulties have been experienced with the plants described. It was thought that the high magnetizing current which occurs at switch-in might cause undesirable voltage fluctuations, and in one large machine provision was made for the later insertion of resistors to limit this current. Special features of this kind do not appear to be necessary and it is known that the magnetization current is high for only a very short time.

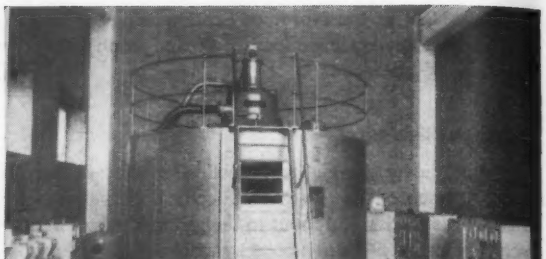


3 *Mullardoch induction generator: switch-in at various speeds*

The current and voltage experienced in actual switch-in conditions are shown in Fig. 3 which records results obtained by oscillogram from switching-in a 2·4MW machine. Voltage drop in the circuits carrying the generated output also has to be considered because there is no control of power factor as there is with a synchronous machine. Here again no real difficulties have arisen and generally it is true that if the connecting line or network is adequate for the load capacity,



4 *Pitlochry power station: 50 kW machine*



5 *Dalchonzie power station: 4 MW*

problems of voltage drop on load and at switch-in do not occur.

The satisfactory operating experience gained gives every encouragement to apply induction generators in all suitable cases and indeed to consider larger sizes. Fig. 4 is a photograph of a 50 kW machine at Pitlochry power station. Fig. 5 is a photograph taken at Dalchonzie power station (4 MW).

621.313.332—82

Design trends in low-drift d.c. amplifiers

This is a brief article relating to a Measurement and Control Section paper (3227) entitled 'A low-drift transistor chopper-type d.c. amplifier with high gain and large dynamic range' by I. C. Hutcheon, M.A., A.M.I.Mech.E., Associate Member, and D. Summers. The paper was published individually in March 1960 and will be republished in Part B of the Proceedings. It was read on the 15th March 1960 before the Measurement and Control Section at Savoy Place (see p. 386). The authors are with George Kent Ltd.

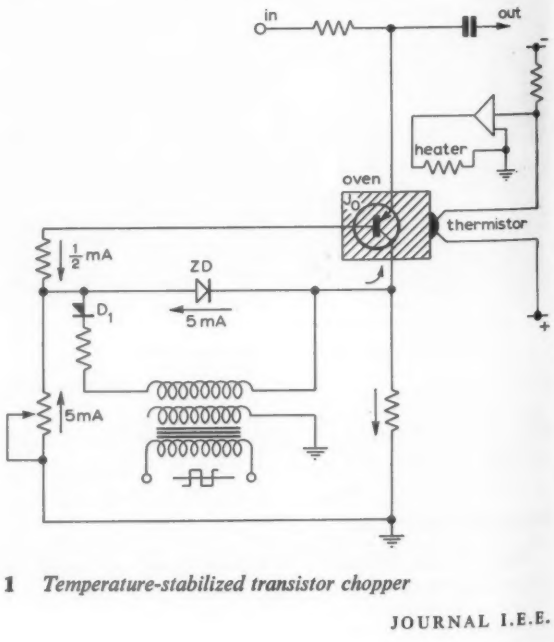
THE smallest signal which an amplifier can detect is determined by the noise developed in its earlier stages, the first stage almost invariably being the limiting factor. In d.c. amplifiers the higher-frequency noise components are usually attenuated, and only the lower-frequency components are significant. These 'drift' effects are measured in terms of the compensating signal required to be applied to the input terminals. It is always important to know or to specify the period of time over which a given drift may occur.

Negative feedback can be used to stabilize the incremental gain of an amplifier but never improves the signal/drift ratio: consequently much effort has been expended in devising various d.c. error detectors having very low drifts over long periods. These must possess in fair measure the usual virtues of reliability, low cost, small size and immunity to environmental changes, and the great majority (though not all) employ the principle of modulation.

Most of the earlier types of d.c. error detector are mechanical devices containing moving parts, and in general these still provide the lowest drifts.

Capacitor and contact modulators

The vibrating capacitor modulator, for example, is made commercially with a short-term current drift as low as 10^{-16}amp and a voltage drift in the region of 100μV from day to day, or 10μV per hour. It is therefore ideal for the measurement of extremely small currents or fairly low



1 *Temperature-stabilized transistor chopper*

voltages associated with very high source resistances, but the care needed in preparing and ageing the vibrating surfaces makes this type of modulator expensive to produce.

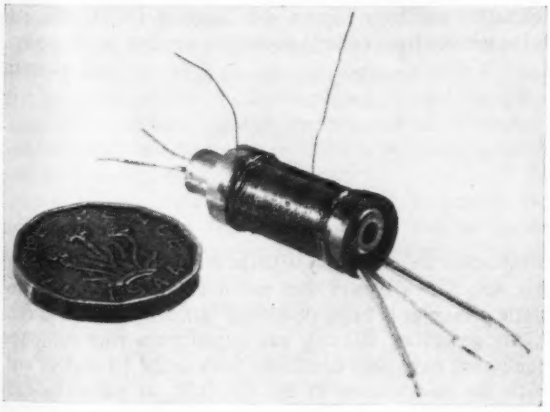
The mechanical chopper or contact modulator on the other hand is particularly suited to low-voltage measurement, and commercial designs exist whose voltage drift remains below about $1\,\mu V$ indefinitely, while laboratory choppers have been made having short-term drifts in the millimicrovolt region.

Maintaining simultaneously a low rate of contact wear, low thermal e.m.f.'s due to contact friction, and reliable contact operation, however, presents considerable design and production problems, and the cost is substantial, though less than that of the capacitor modulator. A current drift of about 10^{-11}amp is quite readily obtainable, but several factors, including contact-potential effects between moving surfaces and piezoelectric and electrochemical effects in insulators, conspire to make further reduction more difficult.

Electromagnetic devices

The most reliable detector is almost certainly the magnetic modulator, which has been developed intensively in various forms since 1945 and has the valuable advantage, when series feedback is not applied, of permitting complete d.c. isolation between input and output terminals of the amplifier. Unfortunately its performance does not approach that of the capacitor and contact modulators, and extreme measures are needed to reduce the drift below 10^{-15} watt from day to day.

A somewhat similar device has been developed in the United States for use with d.c. position servos, in which the feedback



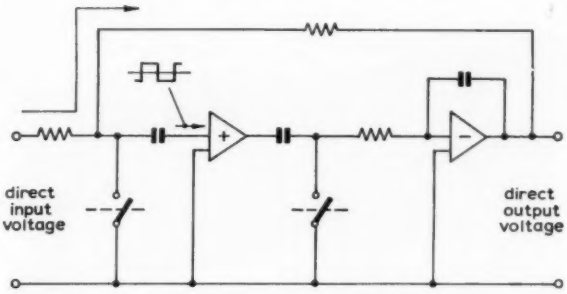
2 *Transistor oven*

flux is altered by rotating a permanent magnet in relation to the core. The error is an a.c. signal which can be amplified and used to re-position the magnet.

Another electromagnetic device is the galvanometer, which in modern industrial guise may be a small robust unit containing an electronic displacement pick-off and stable to about 10^{-14} watt. Analogous electrostatic devices do not seem to be available in robust portable form and may deserve more attention than they appear to have received.

Solid-state modulators

Developments in the semiconductor field have recently given rise to a number of solid-state modulators which provide moderately low drifts and offer considerable advantages in other respects. A number of physical phenomena can be used as the bases of modulation, and two which show



3 *Chopper-type amplifier with feedback integrator*

promise are the Hall and photoconductive effects in suitable semiconductors. The drift of a photoconductive chopper manufactured commercially in the United States, for example, is given as $2\,\mu V/h$ at an impedance of 1 megohm. Diode pairs and transistors can also be used as low-drift switches, the latter being the more attractive on account of their lower voltage drift.

A single germanium transistor, for example, used as an on–off switch, can be arranged to have a drift below about $100\,\mu V$ and 10^{-8}amp, the latter figure being capable of reduction by a factor of at least 100 if a silicon transistor is used. Reducing the voltage drift is more difficult, but $10\,\mu V$ or better can be achieved if the temperature of the transistor is stabilized within a few degrees, if the supply waveforms are stable, and if the operating frequency is not too high.

Transistor oven

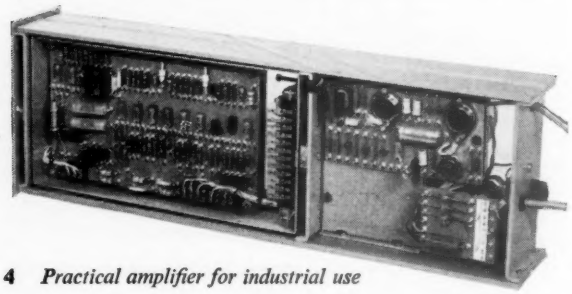
Fig. 1 shows a circuit which enables the voltage drift to be held below $10\,\mu V$ for long periods, and below 2 or $3\,\mu V$/day in temperate conditions. A single square-wave supply voltage, stabilized by a Zener diode, switches the transistor on and off and compensates for its voltage offset, while a small oven maintains the temperature of the transistor within $\pm 2°$ at about 50°C.

Fig. 2 shows a suitable oven which is not much larger than the transistor. Its temperature is detected by a small thermistor mounted at one end and is controlled by a simple amplifier, comprising two or three transistors, and a heating coil wound on the outside. The heater power required is about 1 watt, and the cost of temperature stabilization is not high. An advantage of this arrangement is that the switching transients developed in the transistor are also stabilized, and any offset which they cause remains constant and can be backed off if necessary.

The simplest form of carrier-type d.c. amplifier employs a modulator, a.c. amplifier, demodulator and smoothing circuit,

d.c. feedback generally being applied over-all to stabilize the gain. This arrangement has a limited frequency response and, if a wide bandwidth is required, must be used in conjunction with another amplifier which is capable of handling the higher frequencies.

In less-stringent applications the simpler system alone will often give adequate results. If modulation and demodulation



4 *Practical amplifier for industrial use*

are both full wave, for example, the useful bandwidth can be made to approach the carrier frequency, while even a half-wave system (which offers useful circuit simplifications) can in principle respond fully to any change of input signal within less than one cycle of the carrier. These potentialities are far from realized in most practical amplifiers, but they can be approached if the demodulator and smoothing circuit are suitably designed.

Use of feedback integrator

In the half-wave system, the smoothed d.c. output must drift by not more than a certain amount (which depends on the specified over-all accuracy) during the inoperative part of each cycle, and yet should be driven as fast as possible when an input signal is applied.

This dual requirement can be met by providing as much useful d.c. gain as possible after the demodulator, preferably in the form of a feedback integrator. The demodulator then works normally at a low signal level, is capable of handling the much larger signals which occur during a rebalancing operation, and can change the output by a large amount during one cycle. Fig. 3 shows a typical arrangement, the d.c. amplifier having the lowest drift which can be obtained with reasonable economy, and commensurately high gain.

Practical amplifier

Fig. 4 shows a practical amplifier which has been developed on these lines for industrial use, and delivers a direct current of 0–10mA into any resistive load up to 2 kilohms. The forward gain is such that, when over-all d.c. feedback is applied, the accuracy is limited only by the feedback resistors and by the drift, this being below $\pm 10\mu V$ and $\pm 4 \times 10^{-9}$amp in ambient temperatures between 0° and 50°C.

Complete rejection of common-mode input signals up to 300 volts d.c. or a.c. is achieved by enclosing the entire amplifying section in a conductive screen connected to the source, and passing the d.c. output through a magnetic type of d.c. isolator having a gain of unity, stable within $\pm 0{\cdot}1\%$.

The whole system operates from a 200c/s square-wave supply, which is provided by a transistor d.c. regulator and relaxation oscillator from a d.c. input of 18–30 volts, this being derived from either a battery or a mains power pack.

621.375.422

Electrostatic dust monitor

A short article based on a Supply Section paper (3184) with the above title by D. H. Grindell, Ph.D., B.Sc.(Eng.), Graduate. The paper was published individually in January 1960 and will be republished in Part A of the Proceedings. It was read before the Supply Section at Savoy Place on the 16th March 1960 and a report appears on p. 387. The author is in the Research Laboratory, Associated Electrical Industries (Rugby) Ltd. (formerly the British Thomson-Houston Co. Ltd.).

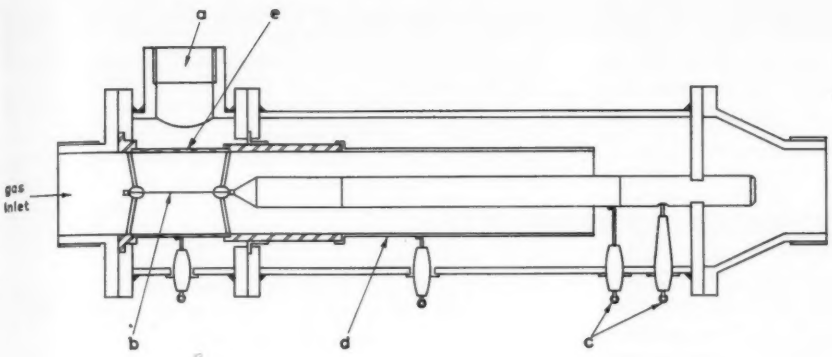
THE problem considered is that of recording the quantity of dust carried in exhaust gases. A quantitative estimate may be required in certain chemical processes if the dust must be recovered for economic reasons. In other processes, for example in the manufacture of beryllium components, monitoring apparatus may be needed to give warning should excessive quantities of toxic beryllium dust escape the air filters and reach the atmosphere.

More generally, dust-monitoring equipment is necessary in large boiler installations to assist in maintaining efficient combustion and to comply with the requirements of the Clean Air Act. A new type of dust monitor incorporating electrostatic principles is being developed primarily for use in electricity generating stations, and experiments with prototype equipment have been conducted both in the laboratory and, with the co-operation of the C.E.G.B., at pulverized-fuel-fired installations.

One present method of determining chimney emission consists in measuring the extinction of a beam of light projected across the flue duct, calibration being in terms of the Ringelmann smoke scale. Alternatively there are gravimetric techniques, in which the dust-laden gas is sampled and filtered. The latter are sometimes difficult to carry out and do not provide an instantaneous reading.

Charged by corona

In the electrostatic method now described a continuous sample of flue gas is passed through a section (Fig. 1) in which the dust particles are charged by corona from a thin wire or



1 *(left) Dust monitor*
a Scavenging air inlet
b Corona-discharge wire
c H.V. bushings
d Particle-collecting electrode
e Wire-mesh electrode

2 *(below) Prototype electrostatic dust monitor showing method of mounting in a chimney duct*

pointed conductor to which a high negative voltage is applied, as in the conventional electrostatic precipitator. The charged smoke or dust particles pass into a measuring section where they are driven by a non-ionizing electric field to a collector. The resulting flow of charge constitutes a current which is recorded.

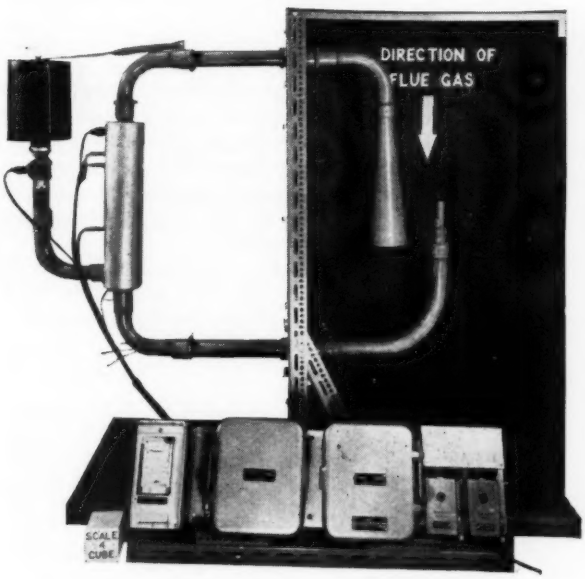
Since the amount of charge acquired by a particle in corona is, other factors remaining constant, governed by the surface area of the particle, the method provides an instantaneous measurement of total external dust surface area sampled by the apparatus per second.

Design and proving tests

The initial electrical design resulted from laboratory tests in which various dusts and smoke were entrained in room air and the results were observed of varying the particle charging and collecting conditions. Proving tests on site followed, with the instruments installed to monitor gases leaving the precipitators, to discover how corrosive flue gases and coal-ash particles affected performance and constructional materials and to gain experience in designing reliable equipment needing minimum maintenance.

A number of problems were encountered, concerning for example dust build-up and its consequences and achieving the correct isokinetic sampling rate; the importance both of effective heating and lagging of the sampling pipes and of automatic self-cleaning was quickly realized.

A number of prototype equipments have been installed and these are undergoing comprehensive field trials. Fig 2 shows the method of mounting and relative size of the apparatus.

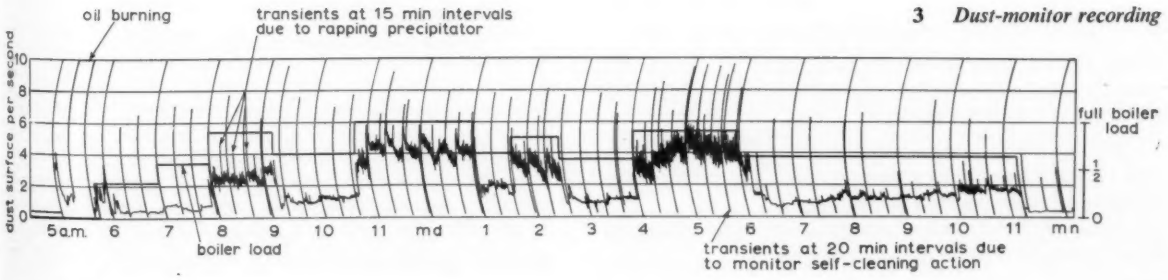


Interpretation of results

An example of a typical recording obtained with one of the monitors is shown in Fig. 3. The instrument has a short response time so that rapid changes in dust burden are reproduced on the chart.

The general trend of the recordings follows the boiler-load

3 *Dust-monitor recording*



curve, and some of the daily routine boiler operations appear on the charts. Fuel-oil burning gives rise to a large number of extremely fine particles, and when the boiler is started up this is indicated as an off-scale reading. The equipment was installed between the precipitation plant and the induced-draught fans, and the regular transient increases in dust burden coincide with the rapping cycle of the precipitator outlet treater.

621.359.4: 621.311.18

PREVENTING CRANE COLLISIONS ELECTRONICALLY

A brief article based on a Graduate and Student Section paper with the above title by R. J. Meredith, B.Sc., Graduate. The paper was read at Rugby before the Rugby Graduate and Student Section on the 7th January 1958 and was awarded a premium by the Council. The author is with Associated Electrical Industries (Rugby) Ltd.

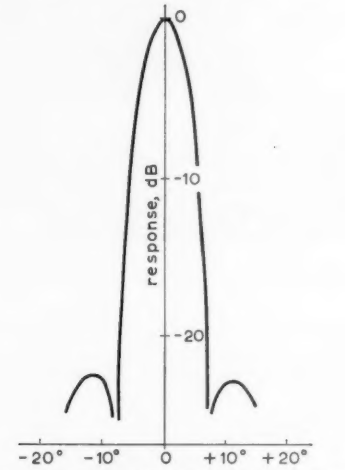
EACH year several accidents occur in which overhead cranes working on the same tracks collide with one another or with men engaged on track maintenance. In the past a great many safety alarm systems have been tried to give warning to the crane driver that an obstacle is in his path, but none has been entirely successful owing to the unfavourable environment frequently encountered.

The paper describes the development of a new safety device which has been used with some success, in which acoustic pulsed radar detects the presence of obstacles in the path of the crane. The main requirements of safety equipment for this duty are that it should:

(1) give audible or visible warning of any obstacle in the path of the crane within a given distance and perhaps give emergency braking in some applications

(2) be inherently safe in that possible faults in the equipment should cause the alarm systems to operate

(3) be reliable in unfavourable environments of vibration, noise, smoke, dust, corrosion and high temperature, such as may occur in steelworks for example.



1 *Loudspeaker radiation pattern*

The advantages of the acoustic radar technique are that no extra track conductors are required beyond those supplying power to the crane; maintenance personnel have merely to erect a reflector for their protection; and the system is not materially affected by dust and smoke.

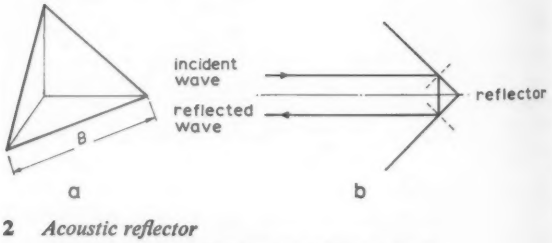
Principle of acoustic radar systems

A horn-type loudspeaker directed parallel to the crane track emits short oscillatory pulses at regular intervals. This loudspeaker is also used as a microphone and is connected to an amplifier which is switched off during the emitted pulses. The adjacent crane carries an acoustic reflector on the axis of the loudspeaker. The pulse echoes from the reflector are received by the loudspeaker, amplified and timed.

The time-delay between the return echo and the emitted pulse is proportional to the distance from the loudspeaker to the reflector (the range is approximately 6in./millisec). If the echo returns in less than a preset time corresponding to the reflector being dangerously close to the loudspeaker (e.g. 70ft) a relay opens and an alarm circuit is operated.

Effects of factory noise

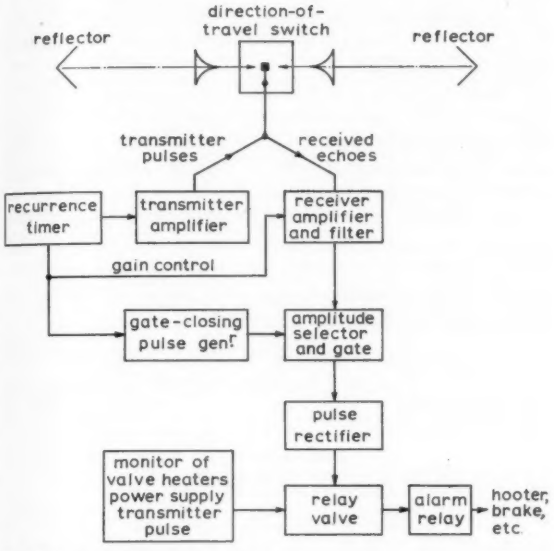
One of the problems peculiar to acoustic radar is the effect of factory noise. The system described above would be particularly prone to false alarms from factory noise because the alarm circuit is in effect connected to a microphone and amplifier. However whereas factory noise is mainly random in character the pulse is a coherent signal. It is therefore possible to discriminate against random noise because the



2 *Acoustic reflector*
a acoustic trihedral reflector: effective area $B^2/\sqrt{3}$
b action of reflector: two-dimensional equivalent

pulse length, oscillation frequency, and direction from which the echoes will return are known.

Considerable isolation from factory noise can be achieved by tuning the receiver amplifier to the oscillatory frequency of the emitted pulse, using a narrow-band filter. In selecting the amplifier bandwidth, allowance must be made for the pulse bandwidth and for changes in frequency of the echo pulse due to the Doppler effect, as there is relative motion between the crane and the reflector.



3 *The acoustic radar system*

Further rejection of factory noise is achieved by using a loudspeaker with a narrow-beam radiation pattern. It would appear that maximum isolation from factory noise and maximum return echo would be obtained from the narrowest beam possible. However crane chassis frequently distort when carrying heavy loads. This causes the loudspeaker axis to be directed away from the reflector so that if the beam is too narrow the echo may be lost. A loudspeaker with a radiation pattern as illustrated in Fig. 1 is a suitable compromise and gives a high discrimination against factory noise when mounted on a crane 50ft or more above the factory shop-floor.

Reflector and echo amplitude

The acoustic reflector (Fig. 2) consists of three mutually perpendicular surfaces intersecting at a point. This reflector has the property that any incident wave is reflected back along a path parallel to the incident wave. The reflector can be shown to be equivalent to a plane reflecting surface placed at the apex of the reflector, having a surface area of $B^2/\sqrt{3}$, where B is the length of one side of the equilateral triangle forming the mouth of the reflector.

The echo amplitude follows an inverse-fourth-power law with distance. Using a loudspeaker horn with the polar diagram already described and a 2ft 8in. reflector, the echo power is about 1/10000 (i.e. −40dB) of the emitted signal at a range of 60ft.

Electronic circuits

A block diagram of the equipment is shown in Fig. 3. The recurrence timer (a conventional multivibrator) generates 20millisec pulses at a repetition frequency of 5 pulses/sec. These pulses are used to modulate a 10kc/s oscillator. The output is applied to the transmitter amplifier and connected via a direction-of-travel switch to the appropriate loudspeaker.

During reception, echoes are applied to the receiver amplifier, which incorporates a filter tuned to10kc/s, and are then passed on to an amplitude selector and gate. If the echoes are large enough and the gate is open, they are passed on to a rectifier, and the resultant d.c. signal is used to open the alarm relay.

During transmission the receiver amplifier gain is much reduced by a pulse derived from the recurrence timer, and at the end of each transmitter pulse a signal is applied to the gate-closing pulse generator. This starts a time-delay circuit whose period is proportional to the maximum desired alarm range. After the delay a pulse is generated which closes the gate until the end of the next transmitter pulse.

Self-monitoring

The equipment is arranged so that in general faults cause the alarm to operate. Specific faults against which protection is afforded are:

failure of transmitter output pulse (and recurrence timer)
failure of gate-closing pulse generator
failure of valve heaters in power supply
failure of any loudspeaker circuit.

Applications

The system can be used for any number of cranes working on a common gantry, each crane carrying the equipment described. Mutual interference can be prevented by suitably positioning the loudspeakers and if necessary arranging adjacent equipments to have different oscillatory frequencies.

Although the equipment is still in the development stage, experience has already shown that the system is reliable and that the measures taken to exclude the effects of factory noise are effective.

Further developments

More recent work on an alternative system, simpler in conception and based on continuous-wave transmission, has shown very good results.

Range determination in this system is by a plane reflector completing the transmission path between separate transmitter and receiver transducers. These are spaced apart across the crane and angled so that their acoustic axes intersect in the warning range. Equipment for this system is now in production. Transistors are used throughout, and all circuits are designed to fail to safety. 621.396.969: 614.8

CORRESPONDENCE

INSTITUTION PUBLICATION PROCEDURES

I HAVE often felt that the system of publishing the *Proceedings* of The Institution is unnecessarily complicated. The Foreword 'A guide to the *Journal*' in the February 1960 *Journal* has convinced me that this is so.

The *Journal* itself is a credit to The Institution. It is interesting, a pleasure to handle, and a real link between the distant member and Savoy Place. It is not through any shortcomings of the *Journal* that you feel obliged, once again, to explain 'publication procedures, and the relation of certain features in the *Journal* . . . to the *Proceedings*' and to ruefully confess that they 'are often obscure to the reader'.

My view is that the difficulties and obscurities lie not in the *Journal* but in the system it is trying to explain, i.e. the *Proceedings* publishing method and its complexities. The system, with slight modification, has served The Institution well and is perhaps hallowed by tradition, but I consider that it is unadapted to the busy modern world. If we are frank with ourselves, few of us can say that we regularly follow the progress of papers through all the ramifications of proof, reprint, publication in *Proceedings* Part A or B, or monograph or individual paper later to be published in Part A or B, etc. etc.

The random way in which papers concerning a particular field turn up in the various parts of the *Proceedings* makes nonsense of the broad classifications, and is very discouraging to a subscriber to one part. Perhaps, like me, they give up. Those members who persevere with the *Proceedings* find that in a surprisingly short time they have accumulated a mountain of literature, much of which is of no foreseeable interest to them; and I have known people in this desperate state to dismember their copies, retaining only an occasional few pages for future reference.

It seems to me that the complexity could be avoided and a more useful service to members provided if the present rather arbitrary segregation of papers into different channels of publication were abandoned and if, instead, each paper, with discussion, were published separately, in simple numerical order and bearing Universal Decimal Classification references for subject filing. All papers issued during a particular period would be bound together, and these volumes, suitably indexed, would form the *Proceedings*—'the permanent record of The Institution'. Members and working organizations would, however, probably prefer subject filing, and the separate papers could readily be arranged in the way best suited for the purpose.

This should lead to a dramatic simplification of the *Journal*'s treatment of published papers. 'Review of I.E.E. papers' would under the one heading deal with every paper issued during the month, noting under each review 'To be read on . . .' or 'Will not be read', as appropriate. Those to be read will, of course, go through the usual proof-copy and final-copy procedure. From the reviews the member will be able to select the papers which interest him. To simplify ordering, I would suggest that a detachable postcard listing current papers be bound in each issue of the *Journal*.

A further refinement would be to produce the papers in a form ready for filing in a folder obtainable from The Institution. It would give me great pleasure to walk into offices of colleagues some day and to see, instead of the usual grimy copies of the *Proceedings* and a few dusty cylinders (unopened copies), a dignified gold-embossed folder containing those dozen or so papers relevant to the member's interests.

It can be seen that the scheme is basically an extension of the present monograph system to cover all published papers. Hence The Institution would have little difficulty in carrying out the procedure. I can sum up by saying that I believe the simplicity of the scheme will appeal to members and encourage them to take more interest in the published papers. At the same time, the scheme will rationalize The Institution's publishing procedure and avoid waste.

It is obviously not possible to cover all aspects of this proposal in a letter, and, in any case, I wish to emphasize that I am not really qualified to do so. I hope that these remarks will be taken merely as a suggestion aimed at provoking discussion among members.

W. E. HUMPHREY, ASSOCIATE MEMBER

c/o H.M. Underwater Detection Establishment

4th March 1960 Portland, Dorset

ELECTRICITY SUPPLY TARIFFS

IN his interesting article on the supply system in France (March 1960 *Journal*, p. 157), Mr. J. Harley notes the use of a three-rate tariff to encourage a higher load factor, but am I right in thinking that this applies only to industrial consumers?

In Britain it has usually been argued that (a) the cost of multiple-metering equipment would make the variable-rate system uneconomic for domestic consumers and (b) the fuel cost is so high a proportion of total generating costs that it is not economic to go to extreme measures to improve load factor. The second argument will eventually be undermined by the increasing proportion of nuclear power stations.

But some economists say that the capital investment in the supply industry is dangerously high in terms both of the money value as a fraction of the national capital investment, and of the absorption of the resources of the engineering industry; and that there are arguments as to cost of marginal units to support the view that the average cost per unit is not a sufficient criterion for examining the economics of load factor.

The distinction between summer and winter months in terms of the minimum charge on domestic tariffs is not satisfactory, since it does not discourage the use of large quantities (well over the minimum) in winter. But is it still impracticable to arrange off-peak metering for the larger domestic consumer who takes upwards of 2000 kWh per quarter?

D. A. BELL, M.A., B.SC., PH.D., MEMBER

Electrical Engineering Department

The University of Birmingham

26th April 1960 Edgbaston, Birmingham 15

OBITUARY

Obituaries of Honorary Members, Members and Companions only are published in the Journal

PERCY GILMAN ASHLEY

Percy Gilman Ashley, B.SC.(ENG.), who died on the 16th March 1960 was born in Barnsley on the 15th December 1900. He was educated at Hornsey County School and at King's College, London, obtaining a B.Sc.(Eng.) degree in 1922. He received practical experience with Tredelect Engineering Co., Chiswick, and as an air mechanic in the Royal Air Force.

After five years with A. Reyrolle, Hebburn, as a technical assistant on switchgear work, he transferred in 1927 to Metropolitan-Vickers Electrical Co., Trafford Park, where he remained until his death.

He was first engaged on insulation matters in the process section of the research department and then joined the switchgear engineering department in 1929. He was an expert on insulating materials and methods, and besides being the insulation specialist for the switchgear department, his advice and help were willingly given to engineers from other departments.

He was one of the very few practical designers in this country of condenser-type high-voltage bushings. He was responsible for all the condenser bushings used in the company's switchgear and transformers, and had made bushings for voltages up to 750kV. He travelled widely in Europe, in the United States and in India on business.

Of a cheery disposition, he was well liked by those with whom he was associated. His cheerfulness was put to the test when he was stranded by a railway strike in the middle of France shortly after the Second World War, when motor transport and available cash were very limited, and he had to hitch-hike back to Calais on lorries and on an occasional heavily-loaded country bus.

His heart had shown signs in recent years of not being too good. He collapsed from a heart attack in the office and died in a matter of a few hours. He was a member of the J. D. Talbot Masonic Lodge. He is survived by his widow and two daughters.

He joined The Institution as a Student in 1922 and was elected an Associate Member in 1927 and a Member in 1943. He was awarded a Student premium for his paper entitled 'Fuses and fusible cut-outs' which was published in the *Journal* in 1925. H. D.

STANLEY BARNETT

Stanley Barnett, M.SC.TECH., head of the department of electrical engineering at Huddersfield College of Technology, died on the 1st April 1960. He was born at Crewe on the 3rd October 1902 and educated at Crewe Grammar School and at Manchester University. After three years' industrial experience with the English Electric Co. he joined Wedgewood Motor Co., Crewe, as assistant manager in 1926. In 1935 he returned to English Electric as a test assistant, the following year becoming a designer with the company.

He then held appointments in the technical colleges at Middlesbrough and Blackburn before going to Huddersfield in 1949. Here he became engaged in the planning of extensive new laboratories, and of advanced courses, especially in his chosen field of servo-mechanisms.

As a young man he was a keen rugger player; in the war he served in the Observer Corps and Air Training Corps. He was a deacon in the Baptist Church. He is survived by his widow and a son.

A man of great integrity, he was held in high regard by his students, in whose progress he took a vital interest, and by his colleagues, whom he was never too busy to help. His modest and kindly presence will be much missed among engineering teachers in Yorkshire.

He joined The Institution as a Student in 1921 and was elected an Associate Member in 1938 and a Member in 1949. He served on the Tees-Side Sub-Centre Committee from 1944 to 1947. G. W. C.

WILLIAM HENRY BRENT

William Henry Brent, B.SC., who died on the 22nd February 1960 was born on the 25th January 1903. He was educated at Southend-on-Sea High School and at Queen Mary College, London, entering the Post Office Engineering Department as a probationary assistant engineer in 1925 after two years as an engineer assistant with Siemens Brothers, Woolwich. In 1935 he was appointed area engineer at Manchester in charge of line construction. In 1939 he became assistant telephone manager at Glasgow for two years before being appointed regional engineer in the Midland Region headquarters, Birmingham. In this position he took over work on internal plant, particularly exchange equipment, and was responsible for several developments in this field as well as for the direction of the considerable programme of exchange installation carried out in the region during the post-war years.

He was a man of varied interests. In sport he swam, played tennis, and regularly took a winter sports holiday in Austria or Switzerland. He was on a ski-ing holiday leading a party from Birmingham Athletic Institute when he died. He took part in amateur dramatics and in choral societies. In 1950 he took up painting and also achieved some success in this venture. He was a society steward of his church. Perhaps his greatest interest was in people and he left a very wide circle of friends who will miss his cheerful companionship. He is survived by his widow and two daughters.

He joined The Institution as an Associate Member in 1934 and was elected a Member in 1949. He served on the South Midland Centre Committee from 1943 to 1952, being chairman in 1951–52; on the South Midland Radio Group Committee from 1946 to 1951, being honorary secretary from 1949 to 1951; on the Library and Museum Committee from 1951 to 1953; on the Scholarship Committee in 1951–52; on the South Midland Radio and Telecommunication Group Committee in 1956–57; and on the South Midland Radio and Measurement Group Committee from 1957 to 1959. L. L. T.

FRANKLIN EDMONDSON

Franklin Edmondson, M.SC., who was born on the 29th November 1903 died in March 1960. He was educated at Wadham House, Cheshire, at Bowden College and at Victoria University, Manchester. He received practical experience with Galloways and with Mather and Platt, Manchester.

In 1928 he became chief assistant engineer with the English Sewing Cotton Co., Manchester, being appointed chief engineer in 1936 in charge of all the engineering department staff. He joined James Booth, Birmingham, in 1945 as chief engineer and was in charge of all engineering developments at the various works of the company until 1958 when he resigned to take a position with the United Kingdom Atomic Energy Authority at Risley, where he was engaged in the design of plant associated with the manufacture of nuclear fuels.

He joined The Institution as a Student in 1928 and was elected a Graduate in 1929, an Associate Member in 1933 and a Member in 1943. He was a Member of The Institution of Mechanical Engineers and an Associate Member of The Institution of Civil Engineers.

SAMUEL STEEL CAMERON GIBSON

Samuel Steel Cameron Gibson who died on the 4th December 1959 was born at Carlisle in 1874. He was educated at a private school, from which he passed in 1890 to the Glasgow and West of Scotland Technical College to study electrical engineering for three years under Prof. A. Jamieson. He then served a two-year apprenticeship with Piercy and Co., Birmingham, and subsequently secured a position on the engineering staff of the Post Office, his duties being mainly concerned with the maintenance of plant at the Manchester Head Post Office. In 1898 he joined the P. and O. Steam Navigation Co., serving in s.s. *Massilia* and r.m.s. *India*.

He commenced municipal work with the Wimbledon undertaking in 1899 as chief assistant engineer. In 1901 he was appointed chief electrical engineer of the Nuneaton undertaking, then an urban district council. Under his guidance and largely through his drive and devotion to duty, the number of consumers grew from 40 in 1901 to nearly 14000 in 1940.

During the 1914–18 War he served in the Royal Navy (part of

Obituary (continued)

the time in the Seychelles) and attained the rank of lieutenant-commander, R.N.V.R.

He continued to serve as borough electrical engineer of Nuneaton until he retired in 1940, after which he acted for a short time as chief engineer at Tonbridge during the absence of the engineer on war service. He was later on the staff of a firm of consulting engineers in Edinburgh, and finally retired to live in Sussex.

He was well liked and held in high esteem by the members and officers of the Nuneaton Corporation and by the members of the municipal electrical engineering profession generally. He was a dedicated servant of the public and a man of great personality. He took his full share in the life of the local community. He was a very active member of Nuneaton Rotary Club and was keenly interested in sport; in his younger days he played cricket and golf at local clubs. His wife predeceased him and he is survived by three daughters.

He joined The Institution as an Associate in 1898 and was elected an Associate Member in 1900 and a Member in 1920.

T. O.

THOMAS RICHARD OVERTON

Thomas Richard Overton who died on the 19th April 1959 was born at Henley, Otago, New Zealand, on the 9th July 1886. He was educated at Henley State School and part-time at King Edward Technical College, Dunedin, and at the Otago School of Mines, where he qualified as an electrical and mechanical engineer and also as a patent attorney while apprenticed with the New Zealand Government railway workshops.

His first appointment was as an assistant electrical engineer with the Dunedin City Council. Following this he played a prominent part in the development of rural distribution in New Zealand.

He was the first chief engineer of the Central Waikato, Horowhenua, Franklin, South Taranaki and North Auckland Electric Power Boards and thus laid the foundations for the future success of these large rural-distribution authorities. Following his retirement from the North Auckland Board he practised as a consulting engineer and patent attorney.

During the 1914–18 War he served in France with the New Zealand Royal Engineers and the Pioneer Battalion, attaining the rank of captain.

In his youth he was a keen athlete, representing Otago at amateur athletics and winning the New Zealand pole-vault championship. He is survived by his widow, a son, a daughter and six grandchildren.

He joined The Institution as an Associate Member in 1912 and was elected a Member in 1921.

A. O. G.

HENRY JOHN WARD

Henry John Ward who was born on the 29th June 1892 died on the 10th March 1960. He was educated at Plumstead Road School, London, and joined Siemens Brothers, Woolwich, as a junior in 1906, studying electrical engineering part-time at Woolwich Polytechnic. In 1918 he became resident engineer, Hull district, which position he held until 1928, when he joined W. T. Henley's Telegraph Works Co. as an engineer in charge of outdoor contract work.

In 1931 he became assistant to the manager of Henley's Newcastle branch. He was transferred to the technical section of the indoor contract department in 1932, attaining the position of technical adviser and senior engineer of the section, where he remained until his retirement in 1957. He then joined Preece, Cardew and Rider as a consultant.

Among his many activities he visited Bermuda in 1946 to supervise the laying of a 22kV submarine cable for the Bermuda Electric Lighting and Power Traction Co. He was also associated with the early development work on Pluto.

He was a man of wide interests and was generally popular with his colleagues at Henley's and members of the profession with whom he came into contact. His great interest outside his professional duties was his garden, to which he devoted practically all his spare time and which duly showed the result of his labours. He appeared to be particularly fit for his age and was enjoying his retirement, so that his sudden death came as a considerable surprise to his many friends in the industry. He is survived by his widow and a son.

He joined The Institution as a Graduate in 1916 and was elected an Associate Member in 1918 and a Member in 1943.

A. V. B.

RAILWAY MODERNIZATION

THE British Railways modernization programme is now in its fifth year. Electrification work is moving ahead: 1008 route-miles by the end of 1958, a further 110 in 1959 (chiefly the Kent Coast scheme and the 25kV a.c. electrification of the Colchester–Clacton–Walton lines), 200 planned for 1960 (25kV a.c. systems for north of London, south of Manchester, and around Glasgow) and a further 280 route-miles in 1961. By autumn 1961 completion of the Liverpool–Crewe section of the main-line (Euston) scheme will allow resources to be concentrated on the track from Crewe to Birmingham.

New signalling is being installed on a large scale. About 11000 colour-light signals are in use, and during 1960 a further 1000 will be provided (many of the 4-indication type). More power-operated signal-boxes are being built which will do the work of a much larger number of manually operated ones. The automatic warning system is being extended, and five main routes will be equipped by 1963: King's Cross–Edinburgh; Glasgow–Edinburgh (already completed); Euston–Liverpool, Manchester, Glasgow; Waterloo–Bournemouth, Exeter; and Liverpool Street–Norwich (via Ipswich).

Investigation of new forms of insulation for 25kV a.c. electrification is part of an intensive programme of research being carried out by the British Transport Commission. Resin-covered glass-fibre cables have been developed to support the live parts of the overhead electric wires, and their use in service, expected to reduce the cost of both insulation and fittings, is being studied with a view to extending their application.

Automatic identification and recording of freight-wagon movements is also being examined. Electronic apparatus has been developed which scans identification plates fixed to the wagons as they pass by and transmits the information to any selected point.

Transistor techniques have been applied to the control and indicating elements of electric signalling systems, and a number of installations are already working. These techniques are now being studied in relation to signal interlocking and track circuits. They are being compared for robustness with the existing types of track-circuit relay which operate for five years in a sealed box and are exceptionally reliable.

Among other projects under investigation are the development of automatic warning apparatus at the technical development unit at Leyton, London (one of three such units), and the characteristics of a pair of rails used as a waveguide.

Nuclear research tools

A WORKING model, known as Minnie, of a low-voltage condenser bank used for controlled-fusion research at the Atomic Weapons Research Establishment, Aldermaston, has been given to the Royal College of Science and Technology, Glasgow, where it will be employed in low-energy experiments with plasmas. It provides fast build-up of current in discharges through deuterium gas in a straight quartz tube.

Special features of a reactor simulator constructed for the Reactor School at the A.E.R.E., Harwell, are the wide range of power levels which can be registered and its digital display of the positions of fine and coarse control rods.

MONOGRAPHS

published individually this month

Papers accepted for reading at meetings and monographs are first published individually and are republished later in the Proceedings of The Institution; as soon as the separates are available they are described in this feature. The papers are supplied free of charge; the price of a monograph is 2s.

Applications quoting the serial number of the paper, monograph or reprint as well as the author's name and accompanied by a remittance where appropriate should be addressed to the Secretary of The Institution. For convenience, books of five vouchers for this purpose can be obtained in advance, price 10s.

Extension of the dual-input describing-function technique to systems containing reactive non-linearity *Monograph* 383M

R. M. HUEY, B.SC., B.E., O. PAWLOFF, DIPL.-ING., *and* T. GLUCHAROFF, DIPL.-ING., M.E.

KOCHENBURGER's describing function and also the dual-input describing function due to West, Douce and Livesley are well known. These techniques enable the graphical solution of non-linear differential equations in which the non-linear coefficient is associated with the first-order differential term to be obtained. The authors describe an extension of these methods allowing the non-linear coefficient to be associated with any term in the differential equation.

It is shown that the typical non-linearity presented by an iron-cored inductor or by a ferroelectric capacitor may be resolved into a simple feedback system containing a single non-linear element which is independent of frequency, together with elements possessing linear transfer functions. The resulting equivalent block diagram is suitable for analysis by either of the describing-function techniques. As an example, the dual-input technique is used to predict accurately jump phenomena in an iron-cored ferroresonant circuit, and the validity of the equivalent block diagram suggested was also checked by simulation on an analogue computer.

Intermodulation on amplitude-modulated multi-channel line links *Monograph* 384E

J. C. H. DAVIS, M.A., *and* H. O. FRIEDHEIM, B.SC.

THE authors develop a method for estimating the total intermodulation noise power falling into any channel in the transmission band of an a.m. multi-channel line system with many repeater sections in tandem. These sections may be composed of widely varying lengths of cable imperfectly equalized by non-identical amplifiers whose in-band feedback, output load impedance and output network response all vary with frequency. The whole system is loaded so that the signal levels at each intermodulation source are also functions of frequency.

After evolving the basic theory, the authors give methods for estimating the system performance before building an amplifier and also when a model amplifier is available. These techniques are more general than those previously published and are illustrated by examples.

Equivalent circuit and evaluation of eddy-current loss in solid cores subjected to alternating and rotating magnetic fields *Monograph* 385U

N. KESAVAMURTHY, M.A., B.E., M.SC., *and* P. K. RAJAGOPALAN, B.E., M.S., PH.D.

IN eddy currents in solid cores subjected to a pulsating or rotating magnetic field, a general 2-dimensional current distribution is created by a magnetizing winding which restricts the current flow through it in only one direction. In these conditions, the method of evaluation of the equivalent impedance of the system as a whole is difficult to visualize and has not so far been described in the literature. Such an evaluation calls for a concept of the power factor of the magnetizing winding. This is the special feature of the monograph.

The authors examine the usefulness of this concept for the evaluation of eddy-current loss in solid cores and thus offer an alternative method.

To give greater validity to several of the formulae deduced in the paper, these are applied to compute the performance characteristics of a solid-rotor induction machine, and certain conclusions are reached.

Resonance excitation of a corrugated-cylinder antenna *Monograph* 386E

J. R. WAIT, M.A.SC., PH.D., *and* A. M. CONDA, B.A.

RADIATION from an axial magnetic line or slot source on the surface of a corrugated cylinder is considered. It is indicated that the power radiated in a given mode for the structure depends critically on the surface reactance and the circumference of the cylinder. In fact, for certain values of these parameters particular modes are strongly excited and contain most of the radiated power. Numerical results are presented for several interesting cases.

The analysis is extended to an elliptic cylinder whose surface also possesses an inductive reactance. In order to facilitate the solution, it is necessary to assume a special azimuthal variation of the surface reactance. For the model as chosen, strong resonance characteristics are again obtained. This model may be adapted to study the problem of a corrugated panel on a flat metallic ground plane which is excited by a parallel slot source.

Analytical method for predicting the performance of semi-enclosed fuses *Monograph* 387S

C. ADAMSON, M.SC.(ENG.), *and* M. VISESHAKUL, M.SC.TECH.

AN analysis has been made and a design procedure established for fuses other than those using round wire and with or without restricted cross-section for part of the fuse length. Fuses of restricted section are, however, the major interest, since they may be used to give different current/time characteristics by varying their dimensions.

These different characteristics may be predicted accurately by the method indicated by the authors. In all the cases of semi-enclosed tin-strip fuses investigated in this way, very close agreement between predicted and experimental results has been obtained.

Forthcoming Institution events

THE nature of the meeting is indicated by the following key:

E ELECTRONICS AND COMMUNICATIONS SECTION

June 1960

23 *Thursday* Institution Conversazione (at the Royal Festival Hall, London, at 7.30 p.m.) (see April 1960 *Journal*, p. 253)

27–1 July *Monday–Friday* Summer Meeting in Scotland (see April 1960 *Journal*, p. 254)

July 1960

E **21–27** *Thursday–Wednesday* (in association with the International Federation for Medical Electronics) Third International Conference on Medical Electronics (at Olympia, London W.14) (all wishing to attend are required to register; forms are available on application to the Secretary of The Institution) (see April 1960 *Journal*, p. 200, and this issue, pp. 329, 355)

TECHNICAL PUBLICATIONS

FURTHER information and copies of the publications can be obtained from the organizations concerned except where otherwise stated

BRITISH BROADCASTING CORPORATION

Engineering Monograph no. 29 **A summary of the present position of stereophonic broadcasting** by D. E. L. Shorter and G. J. Phillips. London, 1960. 5s.

METHODS of producing stereophonic programmes for sound recording and broadcasting are discussed, with particular reference to reproduction in domestic conditions. The problem of compatible reception on ordinary broadcast receivers is examined.

BRITISH ELECTRICAL AND ALLIED INDUSTRIES RESEARCH ASSOCIATION

Report D/T106 **Intrinsically safe electrical apparatus: relation of igniting current to inductance for a mixture of ethylene with air** by E. R. Wooding and F. Shaw. 6s., postage 6d.

THE authors have determined the proportions of ethylene and air in the mixture which is most readily ignited by the spark from an inductive circuit. Ethylene was shown to be more easily ignited than pentane or carbon monoxide, but less easily than coal-gas or hydrogen.

Report D/T110 **The spontaneous ignition temperatures of inflammable gases and vapours. A critical résumé** by H. G. Riddlestone. 10s. 6d., postage 6d.

THE author surveys the available information on the measurement of ignition temperatures, and discusses lowest values. The use of flameproof or other electrical equipment in hazardous atmospheres is considered.

Report G/T319 **Switching transients measured on the live 132kV system. Comparison with network analyser results** by J. S. Vosper. 15s., postage 6d.

MEASUREMENTS are given of transient voltages associated with the interruption of short-circuit currents during tests at the 132kV Cliff Quay substation in August 1956. The 50c/s recovery-voltage waveform is discussed in relation to estimates of restriking-voltage characteristics. Representation on the E.R.A. network analyser is described.

Report LT/379 **The resistance of sheet insulation to surface discharges** by J. H. Mason. 15s., postage 8d.

THE resistance of thin materials to breakdown by surface discharges has been examined by three methods, at temperatures between 20° and 140°C. Thin films of plastic materials, and thicker sheets of silicone rubber, Perspex and synthetic-resin-bonded laminates, were tested. An Institution paper (3250M) based on this report was published individually in April 1960 (see April 1960 *Journal*, p. 236).

Report O/T23 **The protection of 11kV and 33kV line insulators from damage by power arcs** by A. E. Guile and S. F. Mehta. 12s., postage 6d.

THE authors describe the third stage in an experimental investigation into the effects of power-follow-through arcs on h.v. insulators and the protection given by arcing fittings. Previous stages were described in Reports O/T19 and O/T20 (see December 1958 *Journal*, p. 676, and December 1959 *Journal*, p. 729). The present report describes tests made on various types of pin, post and disc insulator for 11 and 33kV systems and on 33kV bushings fitted with duplex gaps. [An Institution paper (3289s) based on a summarizing report O/T24 will be published shortly.]

Report Z/T118 **Joints in aluminium and aluminium alloy busbars. Experiments on contact resistance** by A. P. Singh. 12s. 6d., postage 6d.

THE author has examined the variation in contact resistance with contact pressure for aluminium and aluminium-alloy busbars. Surface preparations used included abrasion under petroleum jelly, tinning, silver-plating and coating with patented jointing compounds.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH: RADIO RESEARCH

Radio research 1958. H.M.S.O., London, 1960. 3s. 6d.*

DETAILS are given of the progress made during the year in work associated with the International Geophysical Year, the ionosphere and radio-transmission conditions, space research, tropospheric propagation, semiconductors and ferrites, and radio measurements and secondary standards. Work on secondary standards will have application to the measurement of power flux near high-power microwave transmitters. Sporadic-E ionization was investigated with a back-scatter p.p.i., and its diurnal, seasonal and geographical distributions were determined. Tests are being conducted using a selected design of counter to record local lightning flashes, and the data will be used to deduce the geographical density of flashes. A section was formed for work in connection with satellites and other space vehicles.

ENGINEERING INFORMATION SERVICES

Digest of Soviet technology edited by M. M. Barash and P. L. B. Oxley. Annual subscription rate (12 issues) £6 6s., post free†

THIS recently started monthly digest, edited by engineers, provides an express service for abstracting information on technological developments published in the Soviet Union and Eastern Europe. The average delay between original and abstract publication is about two months. Abstracts are grouped in sections covering design and production; metallurgy, welding and foundry production; and instruments and automation. Each section concludes with a contents list of current related publications. The final general section includes brief summaries of articles, book reviews, and notices of inventions registered. A full translation of any original material quoted can be supplied within four weeks of receiving the order.

INTERNATIONAL ELECTROTECHNICAL COMMISSION

Publication 34–1 **Recommendations for rotating electrical machinery** (excluding machines for traction vehicles). Geneva, 1960. 8 Sw.fr.‡ (French/English)

THIS edition differs from the 1953 one as regards definition, rating, temperature rise and rating plates. Other sections are devoted to service conditions, dielectric tests, excess current and torque, commutation test, and tolerances.

Publication 50 (08) **International electrotechnical vocabulary. 2nd edition** Group 08: Electro-acoustics. Geneva, 1960. 10 Sw.fr.‡

DEFINITIONS are given in French and English and the terms in German, Spanish, Italian, Dutch, Polish and Swedish. There are sections dealing specifically with acoustical and electro-acoustic transmission systems, microphones, loudspeakers and receivers, and recording and reproduction. There are eight indexes.

* Obtainable from H.M. Stationery Office
† Obtainable from Engineering Information Services, Kirkham, Preston, Lancs.
‡ Obtainable from the I.E.C. Central Office, 1 rue de Varembé, Geneva, Switzerland.

Publication 98–1 **Recommendations for stereophonic commercial disk records.** Geneva, 1959. 4 Sw.fr.‡ (French/English)

IN this supplement to Publication 98, 'Recommendations for lateral-cut commercial and transcription disk recordings', the most important dimensional features and the recording and reproducing characteristics are given which are necessary to secure interchangeability of records.

Publication 107 **Recommended methods of measurement on receivers for television broadcast transmissions.** Geneva, 1960. 25 Sw.fr.‡ (French/English)

THE methods of measuring the electrical, acoustic and optical properties described apply particularly to broadcast television receivers for monochrome vision reception on 405, 525, 625 and 819 lines and for negative or positive modulation with its associated f.m. or a.m. sound reception.

Publication 1171–1 **Recommended graphical symbols. Part 1—Kind of current, distribution systems, methods of connection and circuit elements.** Geneva, 1960. 6 Sw.fr.‡ (French/English)

THE first 'chapter' deals with currents, distribution, and methods of connecting windings; the second covers conductors, terminals and connections of conductors, resistors, windings and capacitors, and other circuit-elements.

C.I.S.P.R.

Report no. R.I. 14 **Report of the plenary session held in The Hague from the 18th to 21st November 1958.** Geneva, 1959. 25 Sw.fr.‡

IN addition to details of the membership and procedure of the C.I.S.P.R., the reports, recommendations and study questions promulgated since their introduction in 1956 are given in full.

TECHNOLOGY

Mathematics education and industry. A record of a conference of teachers, research scientists, and industrialists held at the University of Liverpool, April 1959. *Technology*, The Times Publishing Co. Ltd., London, 1960. 7s. 6d.

THE conference was intended to enable mathematics teachers to meet mathematicians employed in industry, Government establishments, and research organizations. The proceedings are reported here in abbreviated form. Subjects included the application of mathematics to electrical engineering, its contribution to atomic energy, and the nature and applications of linear programming.

UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE

Rural electrification—Vol. 4 Geneva, 1959. 9s.§

THE seven reports contained in this volume cover topics which have been investigated in six countries—Western Germany, the Soviet Union, the Netherlands, Austria, Czechoslovakia and the United Kingdom. The subject-matter includes wind-driven power stations, wooden and concrete poles, rate-fixing for electricity supply to farms, and technical training.

U.S. DEPARTMENT OF COMMERCE NATIONAL BUREAU OF STANDARDS

Miscellaneous Publication 229 **Research highlights of the National Bureau of Standards.** Annual Report 1959. Washington, D.C., 1959. 55 cents*

THE topics investigated included automatic measurement of very high resistance; an international comparison of instrument-transformer ratio and phase-angle measurements; evaluation of storage batteries; and the electrical properties of nylon. Other dielectrics studied were porcelains, boron nitride, crude oil and oil shale, and fresh and sea water. A ferrites laboratory is being established. Radio studies included ionospheric soundings; conductivity and dielectric constant of the polar ice-cap; and an experimental communication system using meteor trails to reflect radio signals.

Handbook 71 **Specification for dry cells and batteries.** Washington, D.C., 1959. 25 cents*

THIS is the seventh edition of the handbook and replaces the previous one (N.B.S. Circular 559) published in 1955. New types of mercury cell are covered. Specifications dealing with dry cells and batteries for use with transistor circuits are set out for the first time, and transistor batteries are evaluated.

PERGAMON PRESS

The other side of the moon translated from the Russian by J. B. Sykes. Oxford, 1960. 10s. 6d.

THE results are presented of a preliminary study, by the U.S.S.R. Academy of Sciences, of photographs taken from the automatic interplanetary station sent up by rocket in October 1959 (see illustration below). Much of the book is concerned with a description of

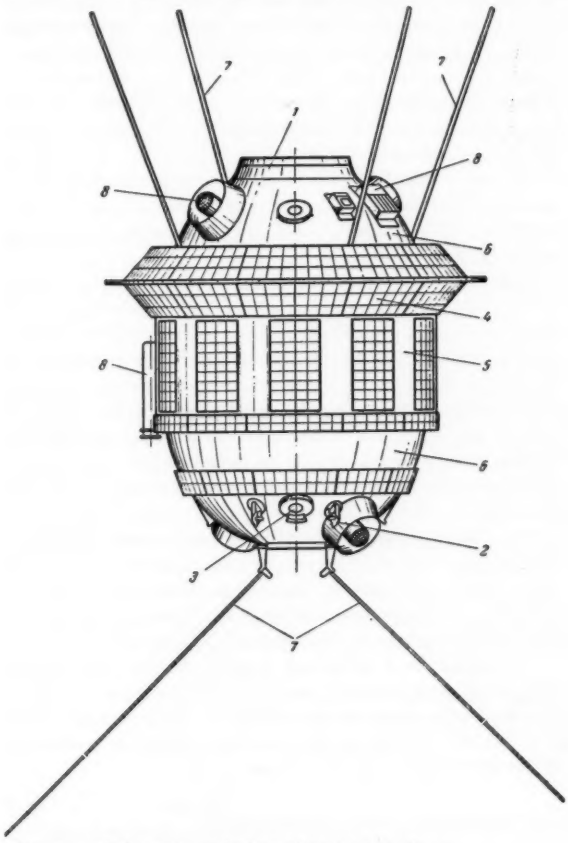


Diagram of the automatic interplanetary station

1 illuminator for photographic apparatus
2 orientation-system motor
3 solar-orientation unit
4 solar-battery units
5 heat-control screens
6 heat shields
7 aerials
8 scientific apparatus

the station, and of the means of directing the photographic apparatus towards the moon, the selection and calculation of orbit, the photographic and television apparatus, and the methods of transmitting the pictures back to Earth. The book concludes with a brief summary of the features of the moon hitherto unseen, as revealed by the new photographs.

‡ Obtainable from the I.E.C. Central Office, 1 rue de Varembé, Geneva, Switzerland
§ Obtainable from the Sales Section, European Office of the United Nations, Palais des Nations, Geneva, Switzerland
* Obtainable from Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

SOME RECENT BOOKS

DIE NOMOGRAPHISCHE METHODE DER BERECHNUNG KOMPLIZIERTER UND STARK GESÄTTIGTER MAGNETISCHER KREISE ELEKTRISCHER MASCHINEN

O. BENEDIKT

BUDAPEST: HUNGARIAN ACADEMY OF SCIENCES. 1960. 288 PP.

THE author was for long a designer in the Soviet Union, and his book is the enlargement of a doctoral thesis of 1937. It treats the neglected topic of highly saturated, complicated, magnetic circuits of rotating electrical machines. This 'non-linear' subject has gained new importance because of the high utilization of materials in modern rotating electrical equipment.

Since the method of successive approximations for the calculation of magnetic flux densities in rotating machines is very time-consuming, a nomographic technique is proposed in the text. With this method the inverse problem of determining the flux-density distribution for a given magnetomotive force in highly saturated circuits and other complicated problems can be solved.

After reviewing present-day design techniques for magnetic circuits, the author presents the principle, the mathematical foundations, and the construction of nomograms for wedge-shaped, saturated ferromagnetic bodies. In the main part of the treatise the following topics are treated in detail: magnetic flux-density and field-intensity distributions in the region of a saturated tooth and adjoining slots of an armature; the magnetomotive force for non-uniform air-gaps; flux-density and field-intensity distribution in the region of highly saturated pole-tips; and the calculation of leakage fluxes.

The method is also extended for a more accurate calculation of iron losses and of eddy-current losses in armature conductors. Three nomograms and more than 100 numerical examples, based on traction motors of Russian design, are used to demonstrate the usefulness of the technique.

The volume is a significant addition to the tools of any designer of large rotating machinery. Unfortunately, experimental confirmation of the method is given only sparsely. The dynamic behaviour of saturated circuits is mentioned in the last chapter, but not treated at all.

AUTOMATION AND COMPUTING

A. D. BOOTH

STAPLES PRESS. 1958. 158 PP. 25S.

THE book is designed to provide an intelligible, but not over-technical, description of both digital and analogue machines, and of automation methods. An interesting account of the history of automation is the subject of an introductory chapter. A discussion follows of the principles of logical design for digital machines and of the basic physical components employed in modern computers. Programming techniques are illustrated in simple examples, the particular application to clerical work being discussed in some detail. Analogue machines, and typical components employed both in mechanical and in electronic analogue devices, are dealt with briefly.

Various aspects of automation are next considered. Open-loop control of continuous industrial processes, and closed-loop control as applied, for example, to machine tools, are described. Certain of the methods for measurement of position in the machine-tool application are outlined. Final sections give further applications of the digital computer, to the less straightforward problems posed by, for example, strategic planning and language translation.

Altogether, there is in the volume much to maintain, and described with a sufficient lack of technical detail to avoid losing, the reader's interest. However, the lack of detail has in a few places been taken too far, resulting in a definite inadequacy of the descriptions or explanations given. Notably, the diagrams and descriptions of position-measurement devices are difficult to follow, and are even misleading for the linear inductosyn.

Despite its few shortcomings, the work should prove particularly suitable as general reading matter for final-year engineering students, as well as for the qualified engineer.

M. J. SOMERVILLE

FUNDAMENTALS OF ADVANCED MISSILES

R. B. DOW

NEW YORK: JOHN WILEY. LONDON: CHAPMAN AND HALL. 1958. 567 PP. £4 14S.

THIS publication explicitly attempts to survey the whole field of theory relevant to the behaviour of a guided missile considered as a time-variant system. It is a work for the mathematically inclined systems man, not for the practical engineer.

The most important part consists of the chapters on kinematics, aerodynamics and propulsion, dynamics, guidance, guided-weapon systems, and probability and statistics, covering about 400 pages. These sections form a unified core of theory, and also convey something of the art of setting about the design of a missile system. They justify the publication of the volume.

The chapter on microwaves does not fit so well into the general systems picture. The treatment is mainly mathematical, and much of the discussion of microwave circuitry, 'plumbing' and valves is probably far too specialized for the systems man, however erudite, while being too brief for the specialist. The account of the characteristics of beams in space will be of more value to the systems man, though even he might do better to turn to less condensed texts, such as in the Radiation Laboratory Series. For instance, the physics underlying reflection from the surface of the sea is not examined; point reflection is implied: this can be misleading at radar wavelengths when the Fresnel zones can cover large areas.

The description of echoing area is brief, and there is no mention of the behaviour of any of the standard shapes, such as the sphere or the corner reflector.

The treatment of infra-red radiation (33 pp.) is at the proper

level for a systems book, as is the chapter on radar, although one or two items of circuitry have been allowed to creep in.

Symbols are defined in the text on introduction, but the lack of any list of symbols is a handicap to the reader.

R. A. LAWS

RADIO STUDIES OF THE UNIVERSE

R. D. DAVIES and H. P. PALMER

LONDON: ROUTLEDGE AND KEGAN PAUL 1959. 200 PP. 25S.

MUCH popular interest is directed towards the study of space and in particular towards the new science of radio astronomy, where there is still a great scarcity of literature. The authors, who are actively engaged in research at Jodrell Bank, one of the world's most famous centres of radio astronomy, present a competent and up-to-date account of its progress for the intelligent non-scientist.

The first few chapters of the volume provide an introduction to general astronomy and outline the radio methods of observation. These are followed by sections dealing with radio sources, including the sun, and our own galaxy, an interesting account of the exploration of the planetary system using radar techniques, and an investigation into the upper regions of the Earth's atmosphere.

The text, written in a chatty style, is copiously supported by quantitative information which may be difficult for some readers to comprehend. Apart from a few minor lapses of balance and clarity, the most disappointing aspect of the book is the line drawings. Some of these seem to have been drawn by a shaky hand, and the lettering on most diagrams presents an amateurish impression. However, the inclusion of several interesting plates largely compensates for this defect.

B. ELSMORE

NUCLEAR TECHNOLOGY FOR ENGINEERS

R. H. ELLIS, Jun.

McGRAW-HILL. 1959. 284 PP. £3 14S.

THE author describes this work as covering the broad range of nuclear technology at a beginner's level. It is not, however, properly a beginner's book because of the too great attenuation necessarily inherent in any attempt to cover the vast field of nuclear theory and radiation technology within the compass of 275 pages, and the author must have experienced great difficulty in deciding what to retain and what to discard.

The treatment, therefore, inevitably exhibits some appearance of dogma, for relatively little explanation can be included, and expressions such as 'powerful physical reasons show . . .' are perhaps not satisfying even to a beginner. Nevertheless, it is possible that this apparent defect may be of value to students in stimulating them to look elsewhere for the missing links, and, as a framework charting the voids, the volume could prove useful. The style is lucid and the language simple. Mathematics is used only when essential, and advanced knowledge is not necessary. The text is carefully illustrated and, within the limitations referred to, the discussion is competent.

The real worth of the publication will be best obtained by readers hitherto ignorant of nuclear technology but requiring an introduction at elementary level to enable them to deal with its impingement on some other engineering subject in which they are already versed, and in this aspect it may be said to succeed by reason of the simplicity and clarity it brings to this large and complex field of knowledge.

Two points of detail are worth remarking. The author, having devoted two or three paragraphs each to the electron, proton and neutron, and noting a later mention of the positive electron and the neutrino, states 'As of this writing most other particles are mainly of academic interest to physicists. But it would constitute a sad lack of imagination not to assume that they may be of important engineering interest when more is known about them.' It is difficult to decide whether, in this context, this remark is masterly or monstrous.

Two pages are devoted to the Heisenberg uncertainty principle and the development of Planck's constant, and, as the author obviously appreciates the difference of outlook in this connection between physics and philosophy, it would perhaps have given a more easily comprehensible understanding to the type of reader aimed at, if the expressions in the opening paragraph had been introduced rather later in this passage.

STATISTICAL METHODS IN RADIO WAVE PROPAGATION

W. C. HOFFMAN (*Editor*)

PERGAMON PRESS. 1960. 334 PP. £4 10S.

IN recent years it has become increasingly evident that, in many studies relating to radio-wave propagation, the maximum information could be derived only by the application of statistical methods. It was the aim of a symposium held in Los Angeles in June 1958 to encourage discussion of both the radio problems and the statistical methods by experts in the two fields.

Some 23 papers were presented and have been printed in this valuable and very well produced volume. They cover a number of aspects of statistical theory, relevant investigations in tropospheric and ionospheric propagation, and aerial design, and there are also two papers on instrumentation for processing propagation data.

The book should be found useful not only by those engaged in propagation research—particularly on scatter transmission problems—but also by students of statistics.

SCIENCE AS HISTORY

H. GARTMANN

HODDER AND STOUGHTON. 1960. 348 PP. 25S.

IN a series of episodes the author of this book sketches in varying degrees of detail the development of invention in several fields.

In contrast to the evolution of the steam engine, the development of modern transport and the rise of aviation, electrical engineering as such is not discussed. The part played by electricity in the field of telecommunication is, however, referred to, but not in the same detail as elsewhere, and the contribution of British engineers does not receive adequate recognition.

Thus the practical telegraph of Cooke and Wheatstone, the enterprise of the British telegraph companies oversea, the part played by the brothers Brett, and later by Sir C. T. Bright in the field of submarine telegraphy find no mention, likewise the fact that the first transatlantic submarine telegraph cables were at this period exclusively of British manufacture.

These are small criticisms in a work which is remarkably free from national bias, and seeks to give credit impartially.

Perhaps its most valuable feature is the excellent survey of modern scientific achievement in nuclear physics, rocket propulsion and the exploration of space. This occupies about one-third of the text and is, in the opinion of the reviewer, ample justification for commending the volume to the attention of the advanced student and qualified engineer.

C. MACKECHNIE JARVIS

AUTOMATION AND SOCIETY

H. B. JACOBSON and J. S. ROUCEK (*Editors*)

NEW YORK: PHILOSOPHICAL LIBRARY. 1959. 553 PP. $10

THIS large book of 32 chapters and two appendices, each contributed by a different writer, is divided into four sections—the concept of automation—automation applied—automation and responsibility—automation and society.

Many of the contributions have been published elsewhere: no fewer than 11 are much shortened versions of evidence given by leading authorities at hearings before a United States Congressional sub-committee in 1955, though no reference is made to this by the Editors. The article by the Russian authors is reprinted from a Unesco bulletin, and the 37 short case-histories of automation in the U.S.A. and Canada are excerpts from the D.S.I.R. report 'Automation in North America.'

A wide field is covered: social, economic, political, labour and management aspects, manufacturing industry as well as the Post Office, railways, accountancy and education (teaching machines). A number of chapters repay study, including that by Prof. Brozen on 'Automation's impact on capital and labour'. The whole forms a useful digest of American thinking on the subject up to about 1957. There is little in it that is new for the specialist, but an electrical engineer or student who wants as much general thought as possible within one set of covers should find his wants satisfied.

There is a 50-page dictionary of automation terms, but regrettably the volume has no index.

L. LANDON GOODMAN

APPRENTICESHIP

K. LIEPMANN

LONDON: ROUTLEDGE AND KEGAN PAUL. 1960. 204 PP. 23S.

IT is difficult to decide the purpose of this volume and for whom it was written. The statistics are too scrappy to be of use to the serious student, and the parent or teacher would find little in the book to help him.

The author, in the terms of modern slang, has 'torn a strip off' apprenticeship and those concerned with it. But it is so long and narrow a strip that it is of little value even as criticism. She attempts to cover all grades of apprenticeship—craft, technician and technological—in three industries as widely different as building, printing and engineering, from a survey confined to Bristol and the surrounding area.

The result is snippets of statistics used to support deductions reached on wholly inadequate information. It is not surprising, therefore, that she should reach the conclusion that 'it would appear that it is not in the best interest of the community that the number of apprentices be left to be determined by industry itself'.

The large engineering firms of this country have a long experience in, and much accumulated information on, apprentice training at all levels, and have worked closely with trade associations and the professional institutions to ensure that the education and training are in keeping with present-day needs. It is unfortunate, therefore, that the survey should have been confined to one large engineering firm, excellent and renowned as it is, which has special problems arising from local conditions and its phenomenally rapid growth. It cannot in isolation represent the engineering of this country as a whole.

The author sees no value in the indenture as a guarantee of good training! What she appears to mean is that the intrinsic value of indentured apprenticeship lies in the reputation and standing of the firm granting the indenture. This, of course, is true and it is also true of technical qualifications. A B.A. degree is of little value unless we know by whom and for what it is awarded; in some instances it spells failure. The facts are that a young man who possesses the indentures granted by a firm of repute carries a hall-mark that is universally recognized and sought after. To leave any other impression is to mislead.

She appears also to have misunderstood the contribution of the professional institutions to the education and training of technical apprentices. To say, as she does on p. 135, that 'the H.N.C. is used as a means of restricting entrance into the ranks of professional qualified engineers' underlines the misconception.

The professional institutions have in the past encouraged and indeed championed the cause of the industry-based student, and they continue to do so. Over the past 30 years more than 50% of their membership has come from this source. The institutions have worked closely with the Ministry of Education, colleges and trade associations to ensure that the courses of study and practical training are arranged in such a manner that within a normal five-year apprenticeship a young man may reach the technical level and complete the practical training required by their bye-laws.

But the National Certificate courses were never intended only for potential professional engineers, and those who obtain the Ordinary National Certificate or the Higher National Certificate without endorsements will have a well-worth-while technical qualification which is recognized throughout industry.

The rising standard of the professional institutions' educational requirements simply reflects the needs of industry, with its rapidly expanding scientific activity. The trend is seen first in the content of university courses. Before the Second World War a normal degree course in engineering continued for two years after the 'intermediate examination'. Today it is a three-year course from this standard, and contains much

more mathematics and physics. There is frequent talk of four years from this entry standard being necessary in the future.

This raising of university standards is naturally reflected in all forms of technical education, and the professional institutions strongly support sandwich schemes leading to the Dip.Tech.(Eng.) and college diplomas for industry-based students seeking to become professional engineers. These courses provide the industry-based student with a fair chance to compete technically with the university student and probably offer him some advantage when the practical training is properly co-ordinated with the technical education.

It is firmly expected that, in the future as in the past, the membership of the professional institutions will contain a high percentage of members who have received their education and training as industry-based students.

G. S. C. LUCAS

ELECTRICAL EFFICIENCY IN INDUSTRIAL PLANTS

E. S. LINCOLN

NEW YORK: F. W. DODGE. 1959. 235 PP. $9.50

ACCORDING to the foreword, this volume by an American consultant on electrical engineering is 'designed to help industrial users save dollars too often wasted in needlessly high power costs, lost or interrupted production, damaged equipment, and misspent manpower', but since, as might be expected, it is based entirely on American practice, much of it will not be of more than passing interest to electrical engineers in the United Kingdom.

The author deals with his subject in a systematic manner in nine chapters, starting with a statement of the case for electrical economy and leading through discussions of industrial power system design under various heads, electrical surveys and their analysis, and electrical instruments to a final chapter on safety, inspection and maintenance; but his treatment, which is never profound, is so elementary in places and so unbalanced in outlook in others that he can hardly be said to have added to the knowledge on the topic.

For example, all the well-known methods of measuring electrical quantities are described in a manner more suitable for the schoolboy than for even the first-year student in electrical engineering, for pictorial instead of diagrammatic representation of the various instruments is frequently used. Then there is a long chapter of 40 pages on power-factor correction, much of it quite good and much that is rudimentary; but safety, inspection and maintenance, all of which have a material influence on the economic performance of an installation, are respectively dismissed in eleven, four and five pages, while flameproof equipment is not mentioned at all.

The chapters on power system design and power system circuits put before the reader in a reasonable manner the various problems to be considered from the point of view of American practice, and there is a good deal of information in the form of tables and diagrams about American standards and requirements which will be of interest but not of much immediate value to the electrical engineer in the United Kingdom.

The book should be of some value to the young electrical engineer in Britain who is about to enter industrial service, for it is a useful guide to the way in which the work described should be organized and carried out. Maintenance foremen and first-year students too should find it helpful in many ways, but it cannot be recommended to the professional engineer.

T. E. HOUGHTON

INSTRUMENTATION IN SCIENTIFIC RESEARCH

K. S. LION

McGRAW-HILL. 1959. 324 PP. £3 14S.

A VERY considerable effort is expended in the course of scientific research on the development of techniques for the measurement of the phenomena under investigation. The degree of success achieved in a project is often determined by the experimental skill of the investigator, and it is well known that many of our outstanding scientists have shown remarkable ingenuity in experimental work. Any book dealing with experimental methods is bound, therefore, to be received with interest by the research worker.

This particular publication is a survey of the electrical transducers used in experimental research for the measurement of mechanical and electrical quantities, magnetic fields, temperature, and radiation. It is comprehensive: a very large number of devices are described, and a critical but limited account is given of the functioning and limitations of each, together with lists of references for further information. The subject-matter can only be described as fascinating.

This is a reference work which will prove to be an excellent source of information on experimental techniques. Research workers in all fields will find it a valuable and stimulating addition to their libraries, and it is strongly recommended to them.

The title actually implies an unnecessary restriction, because the text will also be of great interest to engineers in the field of industrial measurement and control.

TWO-WAY RADIO

A. H. LYTEL

McGRAW-HILL. 1959. 291 PP. £3 14S.

THE purpose of this book, in the words of the author, is to 'explain the growing field of two-way radio communications to the technicians and maintenance men who will be responsible for installation, servicing, and repair.' In the main, and with the reservations noted below, it succeeds in this limited but useful object.

The title is somewhat misleading, since the text is almost wholly concerned with v.h.f. and u.h.f. mobile-radio systems providing communication between cars and base stations, with or without connection to the public telephone network; fixed point-to-point two-way radio systems are only briefly referred to.

In view of his stated purpose, the author makes few assumptions as to the level of technical knowledge of his readers: for example, much space is taken up by elementary explanations of the principles of amplitude-, phase-, and frequency-modulation. Not all the statements made are crystal-clear: for instance, the first sentence of chapter 2 on 'Principles of modulation' says 'FM in mobile communication transmitters

is phase modulation, but by conversion networks is changed to equivalent FM'.

As a review of mobile-radio equipment, techniques and practices in the United States, the work is excellent, the explanation in chapter 7 of selective calling being particularly commendable. However, one reads little about mobile-radio experience outside the United States, and maritime mobile-radio systems are cursorily dealt with. There is little discussion of the propagation of v.h.f. and u.h.f. radio waves and its effect on the service area of mobile-radio systems, or of the problems of planning such systems.

Readers with an eye for the exotic might care to glance at this item from the index: 'Snake, use of, page 229.'

The volume can be commended to technicians and servicing men working on mobile-radio systems and, within its limited scope, to designers and planners of such systems. W. J. BRAY

NUCLEAR ELECTRONICS—Vols. 1 and 2

INTERNATIONAL ATOMIC ENERGY AGENCY. 1959. 830 PP. £2 8s.

THESE two volumes contain between them some 85 papers on electronics applied to measurement in the nuclear-radiation field, originally presented at the Paris international conference of September 1958. As might be expected from the location of the conference, the largest contribution is from France, and rather more than half of the papers are in the French language: the remainder are in English (original or translated).

Vol. 1 is a record of the first five sessions, on scintillation detectors, ionization detectors and gamma spectrometers, fast pulse techniques, 'classical' pulse techniques, and reactor control measurements; Vol. 2 covers the last four sessions, on reactor control simulation, geological and health physics measurements, data-handling and presentation, and transistorized equipment and components.

The range of papers covers a wide variety of specialized topics, from the physics of plastic phosphors to the automatic control of nuclear reactors, and will be of value mainly to specialists in the various fields who were unable to attend the conference. The leading paper in each session, however, is devoted to an authoritative review of the state of knowledge in that particular branch of study, of current developments and of problems still to be solved, and as such will be of more general interest to workers in other branches.

The work as a whole provides a useful over-all picture of the present state of a rapidly developing subject. J. F. HOGG

PHYSICS AND ELECTRONICS IN PHYSICAL MEDICINE

A. NIGHTINGALE

LONDON: BELL. 1959. 292 PP. 30S.

DR. Nightingale follows his father as a teacher and author of lucid introductory science textbooks. There can remain now no doubt that experience in teaching students is the best basis for writing too. The teacher becomes aware of the capacity of those for whom he writes and the aspects of the subject which require detailed elucidation or emphasis. This book, written purposely for physiotherapists and students of physical medicine, is directed to the army of medical people who must understand the apparatus they employ and wish to apply intelligently without becoming blue-stockings or becoming so overburdened with technical studies that they lose the *joie de vivre* and charm that counts—as far as anyone knows—as much towards successful treatment as the electronic devices themselves.

The text gives a wide introduction to physics, with medical examples to illustrate basic principles in mechanics, hydrostatics and heat. Then, with a brief note on the properties of matter, the student is introduced to the laws obeyed by the electric current and led on to the subjects of electronic amplification and power oscillators.

More-advanced chapters deal with the effects of the electric current, or field, on biological matter, with ionic conduction and with dielectric loss and provide much useful information on practical magnitudes and the rational positioning of electrodes. A final section, for the more advanced reader, treats the theory and use of transistors and introduces certain circuit mathematics. Here perhaps there is a little oversimplification, for example in describing the nature of holes in semiconductors, but then the volume is addressed to beginners, and for this need it is without rivals and very timely.

C. N. SMYTH

ELECTRONIC SWITCHING, TIMING, AND PULSE CIRCUITS

J. M. PETTIT

McGRAW-HILL. 1959. 267 PP. £2 18S.

IN recent years a number of books have appeared professing to give an integrated treatment of thermionic-valve and transistor circuits; switching circuits have, however, usually been either completely neglected or dismissed briefly. The present work is devoted to the systematic treatment of circuits for switching, timing and waveform shaping using transistors or valves, and fulfils a real need. It is intended mainly for the student, rather than the circuit designer, and the standard is that of the final undergraduate year of most B.Sc. Engineering courses.

The author begins with a discussion of the transient behaviour of *RC* circuits, the properties of which are fundamental to much of the later text. The switching characteristics of valves and transistors are represented by piece-wise linear approximations and by correspondingly simple equivalent circuits. Chapters are devoted to regenerative switching circuits (multivibrators) and linear voltage sweep generation; Miller integrator-type circuits, including the Phantastron and Sanatron, occupy the bulk of the latter. Analysis of transients in *LCR* circuits and of the pulse transformer leads into a consideration of pick-off circuits and the blocking oscillator. The author concludes with a section devoted to the pulse response of transmission lines and pulse-forming networks.

The treatment throughout is commendably simple and logical, with both analysis and the circuits themselves reduced to essentials. In this respect the author owes much to the approach to switching circuits pioneered by F. C. Williams, as he freely acknowledges. As with other recent volumes in which an integrated treatment of valves and transistors is

claimed, the transistor receives less than full justice; one would have preferred to have seen more examination of transistor circuits in the main text rather than their relegation to problems at the end of the chapters, excellent and useful though these problems are.

SCIENCE AND TECHNOLOGY IN CONTEMPORARY WAR

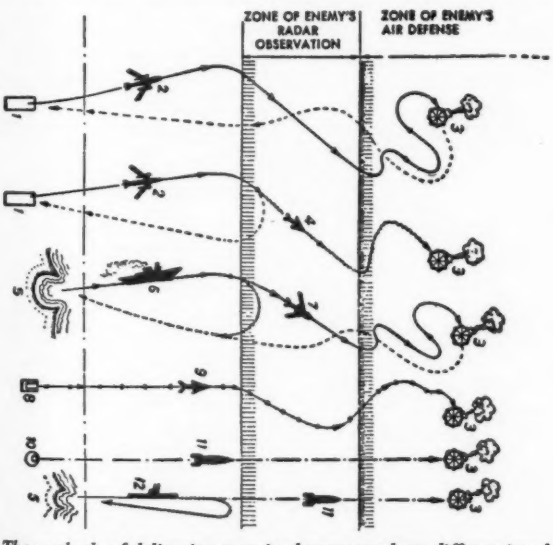
G. I. POKROVSKY

ATLANTIC BOOKS. 1959. 180 PP. 30S.

THE book first appeared in Russia in three separate parts, in 1956 and 1957, the English translation being published in 1959. This explains a certain amount of repetition between the sections as well as the fact that the data in places are not completely up to date.

It is interesting for a number of reasons. First of all, it is probably the first work since the Revolution giving an exposition of Russian thinking on military science; it is plain that the Russians appreciate the importance of science in modern warfare. The author starts from the Engels thesis that the capability of any country to wage war is related directly to its productive capacity. While this is undoubtedly correct in modern times, a criterion which has always been true is that the main requirement of any country being able to wage war has been manpower. Before the Industrial Revolution, this manpower was usually in the field, but now the bulk of manpower is needed in production.

For the successful waging of war, the author emphasizes the importance of informing all concerned of the reason for the war. He arrives at the doubtful finding that Russia is in a powerful position because her reasons for entering any war must always be just, while those of her enemies are bound to be imperialistic. Throughout the volume, the reader is confronted with similar cases of blatant propaganda which detract considerably from its value.



The methods of delivering atomic charges are here differentiated

Numbers indicate: 1 an air base; 2 a long-range bomber; 3 the destroyed target; 4 an air-to-surface missile (i.e. aerial torpedo); 5 a naval base; 6 an aircraft carrier; 7 a bomber; 8 a guided-missile launching pad; 9 a guided missile; 10 a long-range-rocket launching pad; 11 a long-range rocket; 12 a submarine

The author is a major-general in the Russian army, but at the same time he is a physicist on the professional staff of an engineering college and a member of the commission which was responsible for the launching of the Russian sputniks. This no doubt accounts for the fact that, although the text was written before the era of satellites was upon us, the author forecasts accurately their characteristics and significance.

The illustrations include sketches of a number of modern weapons, all of them American. J. S. MCPETRIE

TELECOMMUNICATION DICTIONARY

A. VISSER

AMSTERDAM: ELSEVIER. LONDON: VAN NOSTRAND. 1960. 1011 PP. £7 7S.

THIS dictionary is arranged with an English–American alphabetical base and covers most of the words and phrases commonly appearing in the literature on telecommunication.

Against each English term or phrase is placed the equivalent in French, Spanish, Italian, Dutch and German. There are cross-references from each of the Latin and Germanic languages to the corresponding numbered phrases in English, and, to translate an article in, say, Italian, one would look up the phrase required in the Italian section and would find reference to one or more equivalent English words. It is a convenient feature that against these English words there appears the original phrase serving as a check, and also the equivalent in four other languages, which often helps to clarify the meaning of the translation.

The book should be very useful to those who are engaged in the translation of technical literature, and in particular it should prove invaluable to those engineers who have a slight knowledge of the language but who require a ready means of obtaining the sense of the technical terms. The vocabulary is quite comprehensive, giving nearly 10000 English–American phrases. The volume is very well produced, is easy to use, and is of a quality quite consistent with its rather formidable price.

RESISTANCE AND RESISTORS

C. L. WELLARD

MCGRAW-HILL. 1960. 264 PP. £3 6S.

THIS book is in two parts. Part 1 comprises seven sections (96 pp.) giving the theory, characteristics and materials of resistors; their basic classification, construction, measurement and testing; and some comments on reliability. Part 2—chapters 8 to 29 (160 pp.)—includes comprehensive lists of most types of resistor used for power, instrument and precision applications. The information is largely drawn from manufacturers' catalogues and from scientific papers almost wholly American in origin. Wire-wound, film, and composition resistors are treated, as well as variable resistors, thermistors, potentiometers and attenuators.

Omissions are inevitable in such a broad coverage; in particular, no reference is made to resistors of the precision type wound on flat cards, which have characteristics superior

to those of the bobbin type mentioned, especially for higher frequencies.

Some caution must be exercised in accepting statements made in the theoretical section, because of the somewhat careless use of words. For example, on p. 6 reference is made to the measurement of the e.m.f. of a source by means of an electrostatic voltmeter and it is stated that 'When a current flows the entire e.m.f. is spread over the path between the two terminals of the source'. This neglect of the internal resistance of the source could be misleading. On the same page the word 'superconductor' is used in a context where only a normal metallic conductor at ordinary temperature is meant, instead of the usual meaning—a zero-resistance conductor at very low temperature.

Some confusion is apparent on p. 32, where it is said '. . . measurements to an accuracy of $\pm 3\%$ are possible at 10^{12} ohms, and $\pm 10\%$ at 10^6 megohms'.

Many useful tables and graphs of characteristics are included giving changes of impedance with frequency, temperature, loading, etc.

NONLINEAR PROBLEMS IN RANDOM THEORY

N. WIENER

NEW YORK: JOHN WILEY. LONDON: CHAPMAN AND HALL. 1958. 131 PP. 36s.

THIS publication is compiled from a series of lectures given at the Massachusetts Institute of Technology for a special group of advanced students, to fill the need for a comprehensive study of this subject.

The author is Professor of Mathematics at the M.I.T. and has long been considered one of the world's foremost mathematicians. In a previous work, 'The Fourier integral', written at the instigation of Prof. Hardy and published by the Cambridge University Press (1933), he makes the categorical statement 'It is totally impossible to establish a reasonably complete and symmetrical theory of the Fourier integral except on the basis of the Lebesgue integration.'

The present volume is also based on Lebesgue integration and is a first-class example of how to overcome the difficulties associated with classical or *a priori* mathematics. There is however a much simpler approach based on 'metrical' or *a posteriori* mathematics on the lines advocated by Newton, Kronecker, Brauer, Heaviside, Dirac, Wittgenstein and others. Newton defines number as the measure of a quantity in terms of a unit quantity of the same kind: hence the term metrical.

In the useful arts, quantities are specified with a tolerance, and in metrical mathematics numbers are specified with a tolerance tending to zero (not equal to zero, since this would require infinite information). By closing the limits we obtain the conceptual numbers of classical mathematics, but this closing may be premature and if so may lead to serious but unnecessary difficulties. The author derives, with great difficulty and 'rigour', a 'stochastic function' (which is incapable of being differentiated). He applies it to non-linear problems, frequency modulation, the working of the brain, quantum theory and coding.

The metrical approach would be as follows. The conceptual Dirac impulse function $\delta_L(t)$ has a uniform spectrum similar to that of random noise but has coherent phase and is non-metrical. The impulse of experience is associated with residual reactances so that the spectrum contains neither absolute zero nor infinite frequency. The metrical impulse $\delta_m(t)$ which is the limiting form of this is everywhere continuous and differentiable and leads directly to an unambiguous metrical form of the Fourier integral.

Metrical random noise could apparently be produced by dispersing such an impulse with all-pass networks but cannot be so specified since 'random' cannot apply except to a population or prediction. We can however write $\delta_{m\alpha}(t, \alpha)$ as indicating a $\delta_m(t)$ dispersed by any of a population of dispersing networks indicated by α. $\delta_{m\alpha}(t, \alpha)$ might be described as a metrical 'stochastic function', though it seems preferable merely to regard it as a function of time and of a random variable α. $\delta_{m\alpha}(t, \alpha)$ is continuous and differentiable everywhere.

As the metrical approach, although much simpler, has not as yet been studied in the literature, this book is probably the only source at present for information on the topics discussed, and is therefore essential for a student with a specialized interest in communication theory or related subjects.

PRINCIPLES OF RADIATION DOSIMETRY

G. N. WHYTE

NEW YORK: JOHN WILEY. LONDON: CHAPMAN AND HALL. 1959. 124 PP. £2 16s.

THE purpose of the book is 'to present the special concepts of radiation dosimetry in a coherent manner' with emphasis placed 'on the physical principles of radiation measurements'. Within this framework the author has succeeded in producing a concise and logical exposition of his subject.

Following an introduction to the radiation field, successive chapters deal with the interactions of radiation with matter and the measurement of X-ray spectral distribution, intensity, exposure dose and absorbed dose. Finally there are sections describing the dosimetry of charged particles and neutrons and the use of 'secondary instruments', namely those detectors that do not yield an absolute measure of radiation intensity or dose.

The chapter on the interactions of radiation (charged particles, X-rays and neutrons) with matter is an excellent summary equipped with references to the original literature. The sections covering the measurement of X-radiation show some lack of balance. The author concentrates on radiation produced by machines and treats in a cursory manner the γ-radiation from radio-isotopes that is of primary interest to a worker in the field of atomic energy. In this context it would have been valuable, for example, to have included a discussion of the characteristics of the γ-radiation from a mixture of fission products extracted from a reactor. The final chapter on 'Secondary instruments' is short but adequate for the author's purpose. There is no attempt to give detailed descriptions of the instruments or of their operational use.

To summarize—this monograph gives a clear and readable treatment of the fundamentals of radiation dosimetry. It is recommended to the scientist or engineer seeking a basic understanding of the problems.

*Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members

LIBRARY ACCESSIONS

BOOKS

ABBOTT, P., and KERRIDGE, C. E. 51

National Certificate mathematics—Vol. 1 (First-year course). Revised edition

London: English Universities Press, 1960. pp. xii, 410. 19 × 12·5cm. 9s. 6d.

AMERICAN RADIO RELAY LEAGUE 621.39 (03)

The radio amateur's handbook. 37th edition

West Hartford: American Radio Relay League, 1960. pp. 584. 24 × 16cm. 32s.

BELL, D. A. 621.396.8

Electrical noise: fundamentals and physical mechanism*

London and New York: Van Nostrand, 1960. pp. x, 342. 24 × 15·5cm. £2 10s.

A comprehensive survey of electrical noise and its sources with a section on measurement and standards. The treatment is mathematical and a chapter is devoted to explaining the techniques used. This book was reviewed in the May 1960 *Journal*, p. 312.

IVALL, T. E. 518.5

Electronic computers; principles and applications. **2nd edition***

New York: Philosophical Library. London: Iliffe, 1960. pp. viii, 263. 22 × 14cm. 25s.

An explanation of the principles of analogue and digital computers which will be readily followed by anyone with a modest understanding of the behaviour of thermionic valves. The electronic circuits used for achieving specific operations, such as addition, multiplication, integration and storage, and the construction of complete machines of varying complexity, are explained. Their applications, especially to automation techniques, are described and probable future developments discussed.

JOUGUET, M. 537

Traité d'électricité théorique—Tome 3; Principe de relativité et lois générales de l'électromagnétisme et de l'électrodynamique. (Theoretical electricity—relativity and the general laws of electromagnetism and electrodynamics)

Paris: Gauthier-Villars, 1960. pp. vii, 179. 24 × 16cm.

KLOEFFLER, R. G. 621.38

Industrial electronics and control. 2nd edition*

New York: John Wiley. London: Chapman and Hall, 1960. pp. viii, 540. 24 × 15cm. £4

The emphasis in this edition is on semiconductor devices. The theory of these and of gaseous and vacuum tubes and their use, particularly in control circuits, are discussed and examples of applications for welding, h.f. heating, etc. are described.

LURCH, E. N. 621.38

Fundamentals of electronics

New York: John Wiley. London: Chapman and Hall, 1960. pp. xiv, 631. 24 × 15·5cm. £3 6s.

An introductory textbook covering the various types of thermionic valve and transistor and their use as rectifiers, amplifiers, oscillators, etc. This book will be reviewed in a future issue.

MARGEN, P. H. 621.039

Nuclear reactor optimization*

London: Temple Press, 1960. pp. x, 81. 21·5 × 14cm. 12s. 6d.

Deals with a method of obtaining the optimum economic design of reactor from a number of independent variables without recourse to mathematical computers. The treatment is applicable to all heterogeneous thermal reactor types, but is based on a 250 MW high-temperature gas-cooled reactor with heavy-water moderator.

NOLTINGK, B. E. 001.8

The human element in research management*

Amsterdam, London and New York: Elsevier, 1959. pp. vi, 91. 19 × 13cm. 9s. 6d.

This succinct review of research dwells largely on staff. It stresses the importance of suitable attributes for research, and studies staff relations both vertical and horizontal, promotion and remuneration. Some views on the location of laboratories and on the accommodation provided, including centralized facilities such as workshops and library, are given. Reviewed in December 1959 *Journal*, p. 731.

PHILIPS TECHNICAL LIBRARY 621.385

Industrial rectifying tubes*

London: Cleaver-Hume Press, 1957. pp. x, 116. 23·5 × 16cm. 15s.

Gives operating data on a number of the firm's rectifying valves, but includes circuits, diagrams and information generally applicable to industrial rectifying valves.

SHARPE, J. 621.318.572

Nuclear radiation measurement*

London: Temple Press, 1960. pp. vii, 71. 22 × 14cm. 12s. 6d.

Explains the basic physical operation of detectors rather than their construction; the associated electronic equipment is briefly surveyed.

SMITH, S. P. 621.3 (076)

Problems in electrical engineering (power engineering and electronics) with answers. **7th edition***

London: Constable, 1960. pp. xviii, 370. 22 × 14cm. 20s.

Problems covering first- to final-year studies of degree and Higher National Certificate students are dealt with, the majority being stated in M.K.S. and C.G.S. units.

THOMPSON, A. G. 621.791

High productivity in heavy engineering; production, inspection and cost control in welded fabrication

London: Iliffe, 1960. pp. viii, 339. 22 × 14cm. £3 5s.

This is not about the techniques of welding, but about the technology of an industry employing arc-welding. It deals with works lay-out, production processes and management control.

WELLARD, C. L. 621.316.8

Resistance and resistors*

New York and London: McGraw-Hill, 1960. pp. vii, 264. 23·5 × 15·5cm. £3 6s.

A comprehensive collection of practical information on resistors of all types used in electronic equipment. This book is reviewed this month on p. 379.

Library accessions (continued)

OTHER PUBLICATIONS

B.B.C. ENGINEERING DIVISION

Programme switching, control, and monitoring in sound broadcasting by R. D. Petrie and J. C. Taylor. Engineering Monograph No. 28
London: B.B.C., 1960. pp. 32. 28 × 22cm. 5s.

A summary of the present position of stereophonic broadcasting by D. E. L. Shorter and G. J. Phillips. Engineering Monograph No. 29
London: B.B.C., 1960. pp. 27. 28 × 22cm. 5s.

INTERNATIONAL TELECOMMUNICATIONS UNION

General plan for the development of the international network 1958–1962—Part I
Geneva: I.T.U., 1959. pp. 244. 25 × 18cm. £3 3s.

ORGANISATION FOR EUROPEAN ECONOMIC CO-OPERATION

12th survey of electric power equipment
Paris: O.E.E.C., 1959. pp. 132. 27 × 21cm. 10s.

Elections and transfers

The following elections and transfers approved by the Council are effective from the 28th April 1960

ELECTIONS: 1st LIST

Graduates

ARMSTRONG, Terence, B.SC.
BENNETT, Russell
BUTLER, Allan Peter
BYRNAND, Dorrell Sydney John
LOVE, Brian, B.SC., PH.D.
NOAKES, Edgar John
O'CONNELL, Michael Dom, B.E.
PLUMMER, Robert Michael
SCOGGINS, Ian Maxwell, B.A.
SMITH, Brian Watson, B.SC.
TAN, Sebastian
VAN DER WESTHUIZEN, Louis, B.SC.(ENG.)

Students

ADAMSON, Francis Ian
BAMBER, Reginald
BARKER, Kenneth David
BELL, Malcolm Alexander
BIRKIN, Michael Sambrook
BULLIVANT, Christopher Bernard
BURRAGE, Kenneth Walter
CALDERBANK, Gerald
CHAPMAN, Colin Robert
CHIA, Cheng-Song
CONEYBEARE, John Quinton
EADE, Robert Francis
EVANS, John Hadley
FERRIER, John Henry
FINNEMORE, Michael Philip
FLYNN, James
GARDINER, Alexander Battison
GARDINER, John Graham
GRANT, Leonard Trevor Ingram
GREEN, Charles Walter
GRIFFITHS, Glyndwr, B.SC.
HALL, John
HANSFORD, Richard Leslie
HILL, John Robert
HONEY, George William
HULSE, Dorothy Mary
HURCUM, Ivan Brynley
KATSELIS, George Nicolas
LAIRD, Colin Thoms
LILLY, John Glanvill
LOIZIDES, Andreas Georgiou
LONGSTAFF, Bernard
MACKIE, Alastair Crawford
MARKS, David Gerald
MITCHELL, Christopher John Harrison Webb
MURRAY, Barrie Edward
MURRELL, Anthony Ernest
NOBLE, Anthony Edward
ORAM, Peter
PITT, Stanley
PRAGNELL, Barry Stephen
PUGH, Michael
SHARPE, Anthony John
SMITH Richard Dawson Cox
UPHILL, Arthur John
WEAVER, Richard Owen
WIDDALL, John
WILLS, Edmund John

TRANSFERS: 1st LIST

Student to Graduate

ARORA, Blackie Ighovberhai, B.SC., M.SC.
BAXTER, Robert Ogilvie, B.A.
BELLAMY, Norman West, B.ENG.
BISHOPP, Michael Thomas Albert
COLLINS, Michael Anthony, B.SC.(ENG.)
HARLEY, George Frederick, B.SC.(ENG.)
JONES, Arthur Howard, B.SC.
LEWIS, William John Alastair, B.SC.(ENG.)
MARTIN, Colin Lewis, B.SC.(ENG.)
STEPHENS, Robin Everley, B.SC.
STRETCH, Michael Beverley Knighton, B.ENG.
TRAUB, Harry, B.SC.(ENG.)
WILLIS, William David, B.SC.

ELECTIONS: 2nd LIST

Graduates

BAKER, Brian James
BROWN, Aubrey Allan
BROWN, Thomas Graham
EILLEY, Edward Stretton, B.A.
FOYLE, Richard Elton
HAG, Salih Mohamed Ahmed, B.SC.(ENG.)
HAYTER, Donald Thomas
KOLKIEWICZ, Leszek
LING, Uongieh, B.E.E.
McKINNON, Capt. Alistair William Maclachlan, B.SC.(ENG.), R.SIGNALS
MARSHALL, Leonard, B.SC.
MAYO, Roberto Jaime, B.SC.(ENG.)
OZADA, Refet Huseyin, DIPL.-ING.
SPREADBURY, Peter James, M.A., M.SC.
TOBIAS, Abraham Joseph, B.SC.(ENG.)

Students

BAINHAM, John Edwin Laurence
BAKER, Michael John
BEAL, Peter Lionel
DUNSWORTH, Terence Albert
DURLING, John Anthony
EDWARDS, John Denis
FUDGE, Roy Charles
HENDERSON, David Michael Stewart
McCORMICK, Cyril
MUIR, Ian Robertson
MULLEN, Peter James
RAIF, Faiz Avni
REDELINGHUYS, Hendrik Derick
ROBSON, Norman
STEWARD, John Lewis
TEO, Chiang Boon
WARD, Frank
WEST, William Anthony

TRANSFERS: 2nd LIST

Student to Graduate

ATKINSON, Gerald David
BOMFORD, David Anthony, B.SC.TECH.
BOWSHER, Brian David, B.SC.(ENG.)
CALVERT, Patrick Philip Allen, B.SC.
CAPSIMALIS, George Constantine, B.SC.(ENG.)
DIXON, Cecil Jack, B.SC.(ENG.)
EYERS, Maurice George, DIP.TECH.(ENG.)
GRIFFITHS, John Francis, B.SC.
HASTINGS, William, B.SC.
HOLDEN, Richard Martin, B.SC.(ENG.)
HUMPHRIES, Brian Anthony, B.SC.
JELLY, Aubrey Bruce, B.SC.
KIRK, Geoffrey Thomas, B.SC.
LITTLEFIELD, George Frederick William, B.ENG.
PIKE, Donald Brian, B.SC., B.E.
SLATER, Norman Thomas, B.SC.

The following elections and transfers approved by the Council are effective from the 2nd May 1960

ELECTIONS

Associate Members

ALLEN, Robert Ernest
ANDERSON, John Llewellyn Dillon
CARDALE, Jasper George, B.A.
CASHMORE, David John, M.SC.
FRASER, William, B.SC.(ENG.)
HAGGIS, Robert William
HALL, Lt. Peter Denyar, M.A., R.N.
JOHNSON, Charles Alan, M.A.
KENYON, Philip
SCOULLER, Ivor MacNeill
TAYLOR, Ronald Gordon, B.SC.
WOODVILLE, Edward Arthur

Associates

CLARKE, Sidney Leslie
JONES, George
LIGHT, Robert William
ROCHE, James Joseph

TRANSFERS

Associate Member to Member

BAKER, Alfred George
CARTER, James Dixon
DAVIES, Bernard Rees, B.SC.(ENG.)
DE BEER, Charles Loxton
DUNCANSON, William Eric, M.SC., PH.D., D.SC.
KIDNER, Henry Gerald
LYDDIARD, Jack Alfred, B.SC.
MOORE, Raymond Edward
NAYER-NOURI, Houshang, B.SC.
PATTISON, Capt. George Robert Barton, B.SC., R.N.
ROSENBROCK, Howard Harry, B.SC., PH.D.
TATE, Clifford Edward
WEBB, William John, B.SC.(ENG.)
WILLS, Maj. Gerald Michael Berkeley, B.SC.(ENG.)

Graduate to Associate Member

AKINDELE, Theophilus Oluwole
BAKER, Bertram Roy
BARKER, Frederick Henry
BIRD, Gordon Gerald
BLADES, Michael William, B.SC.
BULLOUGH, John Richard
CAIN, William Edwyn, B.ENG.
COWLIN, Michael Laidlaw
CRAWFORD, Derek Richard
CUTLER, Frederick George
DOHERTY, Stephen Norman Frederick, B.SC.(ENG.)
DYGALA, Henry
EGGERS, Anton Friedrich Wilhelm Heinrich
ERROCK, George Alan, B.SC.
FARROW, Leslie William John
FOULDS, Kenneth William Hall, B.SC.(ENG.), PH.D.
GRASSBY, John, B.SC.
GREENLEES, Andrew, B.SC.
GREGORY, Walter
GRIFFITHS, Anthony Philip
GRIMSDALE, Richard Lawrence, M.SC., PH.D.
HAIGH, Douglas Noel, B.SC.(ENG.)

Graduate to Associate Member (continued)

HEAL, Aubrey William
ICETON, John William, B.ENG.
JONES, Kenneth Robert, B.ENG.
JOSSA, John Charles
LANGMAN, Reginald David, B.SC.(ENG.)
LAWSON, Laurence, B.SC.TECH.
LORD, William Robert
LOWE, Harry, B.SC.(ENG.)
LUBBOCK, John Kenneth, M.A., B.SC.(ENG.)
LYE, Fah Yew
MACKEW, John James, B.SC.
MERCER, Derwent Mark Atkinson, M.A., B.SC., PH.D.
MOORE, Bernard William
MOORE, Robert Charles
MORETON, Geoffrey Edward, B.SC.(ENG.)
MORTIMER, Howard Christopher
MURRAY, Edward Douglas, B.E.
NUNNS, Dennis
OVENDEN, David William Drayson
PARRY, John
PAYNE, John Wilfrid Scott, B.SC.(ENG.)
PILKINGTON, Thomas Osburne, B.SC.(ENG.)
POPKIN, Keith Ian
PRITCHARD, John Stuart
RICHMOND, George Edward
RICKMAN, Douglas, B.E.
RUSSELL, George Stanley
SHAW, John William
SHEPHERD, Alexander Donald, B.SC.
SINGLETON, John Edward Peter
STOKER, Maurice Frederick
SUMMERS, Anthony James
SUMMERS, Frank Cecil, B.SC.
SWADLING, John Edwin
WATERMAN, Alan William, B.SC.(ENG.)
WILLISON, William Ernest
WOOD, John Keith, M.SC., PH.D.

The following elections and transfers approved by the Council are effective from the 19th May 1960

ELECTIONS: 1st LIST

Graduates

ALLEN, Frederick Arthur
AYLOTT, Harry
CHANOT, Griffith John Raymond
EDWARDS, Sheila, M.SC.
EVERITT, James Edmund, B.A.
GRAHAM, Brian, B.SC.
HOPKINS, Gwyn, B.SC.
JOHNSON, David Pemberton
KEAVENY, Michael Francis, B.E.
MALLION, David, B.SC.
MOON, Derek John
O'RIORDAN, Padraic Declan, B.E.

Students

BAILEY, Philip Edgar
BHALLA, Bawa Vijay Singh
BOWDLER, Kenneth
BUTTERWORTH, James Edgar
CASEY, Frank
CHONG, Michael Khim Fon
CLOTHIER, Nigel Donald
COZENS, Peter George
DODWELL, Michael William
GREEN, Ronald Albert
HOCKIN, Roger Andrew
HUGHES, Michael
JACKSON, Victor Hubert
JAMES, Maurice
JOHNSON, Hugh Basil Edwin
JOYCE, Peter John
MAHER, Christopher
MASTERS, Kenneth Walter
MAYNE, David Henry
PARSONS, William Geoffrey
SHAPIRO, Jonathan Hilliard
THOMAS, Leonard George
TOKELL, Daniel Anthony
VIJERATNAM, Candiah
WALSH, Ronald James
WATSON, Keith Clifford
WEBSTER, Derek
WHITELAM, John Roger

TRANSFERS: 1st LIST

Student to Graduate

BOLEY, Terence Alan, B.SC.(ENG.)
CRAMMOND, Jeremy John, B.SC.(ENG.)
EWER, George Anthony, B.SC.(ENG.)
LAIN, Richard Neville, B.SC.
TAYLOR, John Owen, B.ENG.

ELECTIONS: 2nd LIST

Graduates

CLARKE, John James
DADA, Jorge Alberto, B.SC., B.ENG.
GOULD, Christopher, B.SC.
HARRINGTON, David George
HUNT, Peter Jeffrey
KARWOWSKI, Wieslaw Antoni, B.A.
LONGSTAFF, Kenneth
MURPHY, Bernard Maynard, A.R.C.S.T.
SCRASE, John Francis, B.SC.(ENG.)
SEONI, Raj Mohan, B.SC., B.E.
WINNETT, Jack Maurice, B.SC.(ENG.)

Students

ASPIN, Norman
BROOKFIELD, John Thomas
BULLINGHAM, John Michael
CHARTERS, James Scott Temple
CLARY, Brian Arthur Edward
COLLINS, Keith Douglas
CRADDY, Peter Ambrose
DANIELS, David John, B.SC.TECH.
DAWSON, Hubert Melvyn
DEAVES, Antony Edwin
DE VILLIERS, Ian Curtis
GOULDING, Harry, B.SC.
GRAY, David John
GREGORY, Dorothy
GRIFFITHS, Graham Ledger
HOWDEN, Alan Percival, B.SC.TECH.
JUDGE, Brian
LEWIS, John Rainsford
MARTIN-ROYLE, Robert Dennis
NIEUWMEYER, Hans
OMAGHOMI, Godwin John
PEAKMAN, Brian
RIDDLE, Hugh Christopher
ROWLANDS, William
ROY-CHOUDHURY, Samir
SQUIBB, Christopher Maurice
STANLEY, Derek Norman
STITSON, James Arthur Robert, B.SC.
TSIPOURAS, John George
WAKEFIELD, Martin Sommers
WEALE, Michael Raymond
WINTERS, Colin Stewart
WORMALL, David John

TRANSFERS: 2nd LIST

Student to Graduate

D'AGUILAR, Vincent Yelverton, D.F.H.
FAULKNER, Anthony John, B.SC.
HEWITT, Roy William Samuel, B.SC.(ENG.)
NARULA, Mohindar Pal Singh, B.SC.
PHILLPOTTS, Raymond Martin
RAESIDE, Daniel, B.SC.
TERRY, Alan James, B.SC.(ENG.)
WEATHERLEY, Keith, B.SC.(ENG.)

The following elections and transfers approved by the Council are effective from the 1st June 1960

ELECTIONS

Associate Members

AIYER, Ponkunnom Narayana Subramani
BOWKER, Fred, B.E.
BROWN, Kenneth Charles, B.SC.
CHARLTON, Peter
COOK, Robert Barker
COSSLETT, Michael Frank, B.SC.
DAS, Jajneswar, M.SC.
HODGSON, John George
KRAUS, Bernard Felix, ING.
LAREDO, Solomon Joseph, B.A.
LARRY, Ronald
McCULLAGH, Lt.-Col. Frederick Mervyn, O.B.E., B.SC., R.E.M.E.
MACKENZIE, Sqdn.-Ldr. John, M.B.E., B.SC.(ENG.), R.A.F.
PRASAD, Raghunandan, B.SC., B.SC.(ENG.)
SEBESTYEN, Laszlo Gabor, DIPL.-ING., M.SC.
SEYDEL, Gabriel Marie Herman
VISSER, Christiaan Abraham, B.SC.(ENG.)
WESTCOTT, Ronald John
WILLIAMS, Ivor, B.SC.

Associates

CROWTHER, Reginald Sutcliffe
DINNIS, Ivor Stanley
FAULKNER, Arthur Howie
HUGHES-JONES, George Edward
WITCOMB, Frederick Lee

TRANSFERS

Associate Member to Member

ANDERSON, John Graham Peter, B.SC.
BEST, Cmdr. Kenneth Barrington, O.B.E., R.N.(RET.)
COATESWORTH, Lt.-Col. David, M.B.E., M.SC.TECH., R.SIGNALS
ECKETT, Sidney Wallace, B.SC.(ENG.)
HIGHAM, James Berry, PH.D., B.SC.
LOCKER, Leonard
McBRIDE, Maurice Graham, B.SC.(ENG.)
McEVOY, Joseph Arthur Vincent, B.E.
PARKER, John, M.A.
PEEL, Edwin
PICKUP, Harry, B.SC.TECH.
PITTENDRIGH, Lenus Walter Duff
POOLE, John Copeland
RHODES, James, M.B.E., B.SC.(ENG.)
RICHARDSON, William Eric
RODGERS, Joseph Ernest
SMITH, Edward Clayton
STRETCH, Kingsey Lewis, M.A.
WEAIRE, Reginald Frederic
WEIGALL, Denny Brome, M.A.
WHITEHEAD, John
WILLIAMS, William Lloyd
WOOD, Herbert Boyne, B.SC., M.E.

Associate to Member

HUMPHREYS, Charles Fogden

Graduate to Associate Member

APPLEBY, Ralph Desmond
ARMSTRONG, James, B.SC.
BERRY, Richard George, B.SC.
BROGAN, Denis Owen
BURWELL, Herbert Edward Philip
COOKSLEY, Charles Graham
COTTAM, Sydney Leonard
DAVENPORT, Roy Alan, B.ENG.
DAVIES, John Parry
DAWSON, Brian Leedham
DEAR, Leslie Donald
DODSON, John Graham
DOUGHTY, Donald John
DUNDERDALE, Herbert, B.SC.TECH.
EDGAR, Peter Geoffrey
ELLIS, William Bernard Keable, B.SC.
EVANS, David Charles
FELTHAM, Vivian Charles
FIRTH, Kenneth
FOWLER, Ian Daveney, B.E., B.SC.
GANGULEE, Amalendu, B.SC.
GAVINE, William Caithness, B.SC.
GOWER, Dennis Noel, B.SC.
HENDEN, Walter James
HEWITT, John Ernest
HIGGINS, Herbert
HILL, Donald Mitchell
HILL, Henry Leslie, B.SC.
HINCHLIFFE, George
HINDLEY, Derek
HOCIEJ, Teodor
HURST, Kenneth
JARVIS, Frank Harry Robert
KING, Kenneth Henry
KITAJEWSKI, Ludomir, B.SC.(ENG.
LEE, Cyril Arthur
McARDELL, Edward John William
MARK, George Wilson, B.SC.
MARSDEN, Alfred Michael
MATHEWS, Raymond Eric, B.SC.(ENG.)
MEECHAM, Allan George
MILES, Peter Arthur
MINSHULL, John Gardiner
NEWTON, Arthur George
NORTHCOTT, Roland Anthony
POTTER, Dennis Norman, B.SC.(ENG.
POTTS, Geoffrey Stuart
PRATT, Stuart William
QUAYLE, Tom
RANCE, Richard, B.SC (ENG.)
RAVEN, William John Joseph, B.SC.(ENG.)
RICHARDS, Kenneth Harold
RICKETTS, Peter William, D.L.C.
RIDLEY, John
ROBINSON, Eugene Julius, D.F.H.
SMITH, David Arthur Coleridge
STULE, Marian Jozef, D.F.H.
WARREN, Reginald Walter
WAYMAN, Cecil John, B.SC.(ENG.)
WEARDEN, Thomas Bertram, B.SC.TECH.
WHITE, John Evans Peel Lovell House
WISE, Brian Dennis
YOUNG, Andrew

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 9TH MAY 1960

	No. of contributors	£	*s.*	*d.*
£1000 and over	8	8685	0	0
£100 to <£1000	32	7181	3	0
£5 to <£100	916	9560	9	3
£2 to <£5	2267	6239	13	7
under £2	28850	15101	16	8
		46768	2	6

APPOINTMENTS AND NOMINATIONS

WIRING REGULATIONS COMMITTEE

ON the nomination of the Cable Makers Association, the Council of The Institution have appointed Mr. G. A. Bowie, ASSOCIATE MEMBER, to serve on the above committee in succession to Mr. J. R. Cox, MEMBER.

B.S.I. CODES OF PRACTICE COMMITTEE FOR CIVIL ENGINEERING (CVCP/-)—CODE DRAFTING COMMITTEE ON THE PREVENTION OF STEEL CORROSION

The Council have nominated Mr. J. H. Gosden, B.SC., ASSOCIATE MEMBER, to serve as their representative on the above new committee.

B.S.I. TECHNICAL SUB-COMMITTEE ELE/51/5—MARINE TRANSFORMERS

The Council have nominated Mr. G. O. Watson, MEMBER, to serve as a further representative on the above sub-committee in addition to Mr. G. J. Tuke, MEMBER.

ELECTRICAL RESEARCH ASSOCIATION—COUNCIL

The Council have nominated Prof. J. Greig, M.SC., PH.D., MEMBER, to serve as their representative on the above council for a further term.

INTERNATIONAL COMMITTEE ON IRRIGATION AND DRAINAGE —BRITISH NATIONAL COMMITTEE

The Council have nominated Mr. B. Donkin, B.A., MEMBER, to serve as their representative on the above committee for a further term.

EXETER CENTRAL TECHNICAL COLLEGE—ELECTRICAL ADVISORY PANEL

The Council have nominated Mr. R. H. Upton, M.ENG., MEMBER, and Mr. G. B. Devey, ASSOCIATE MEMBER, to serve as their representatives on the above panel.

RETIRED MEMBERS AND THOSE OF LONG STANDING

MEMBERS are reminded of a rule which has been in existence for some years, which enables Corporate members and Associates who have retired from the profession and are still desirous of retaining their membership of The Institution to do so without payment of further subscriptions, or at a reduced subscription, depending on their length of membership. It is left to the members concerned to make application to be brought within the rule. The rule, which does not apply retrospectively, is as set out below:

Any Corporate member or Associate who has reached the age of 60 and has retired from the practice of his profession or business may apply to the Council of The Institution to waive or reduce his future annual subscription, depending on the length of his continuous membership as follows:

25 years	full remission
20–24 years	two-thirds reduction
15–19 years	one-third reduction.

If a retired member of 25 years' standing desires to continue to receive the *Journal*, he can do so on payment of 10s. per annum. Parts A, B and C of the *Proceedings* will also be available to him at the appropriate subscription rates.

A further rule provides that as soon as a member of any class completes 50 years of membership he is not required to pay any further membership subscriptions, regardless of whether he is still in remunerative employment. This rule operates automatically, and the member on qualifying is notified accordingly. If he desires to receive the *Journal* or the *Proceedings*, the arrangement for retired members of 25 years' standing applies.

PRACTICAL PAPERS IN THE *PROCEEDINGS*

THE Council of The Institution welcome the submission, for publication in the *Proceedings*, of short papers dealing with practical problems encountered in the development, manufacture, operation or maintenance of electrical equipment. Such papers are useful to other members facing similar problems. They may be quite short, of any length between, say, 500 and 2500 words. A short practical paper has an obvious attraction for the engineer who is too busy to prepare a full-length one, and it provides information in a form which readers can usually assimilate rapidly.

STUDENTS' QUARTERLY JOURNAL

WITH the June 1960 issue, the *Students' Quarterly Journal* completes 30 years of publication.

There are articles on the application of electronics to jet-engine control by H. E. Coles; graphical analysis applied to simple rectifier circuits by C. F. Amor; the protection

of 132kV transmission systems by D. Marshall; European free trade by W. D. Coutts; electrical-plant design using digital computers by B. J. Chalmers; home laundry equipment by J. H. Kingsley; and paradoxes in r.m.s. values by T. Palmer. Discussions of the principles of electronics and impulse voltage testing, together with a report of Sheffield's third week-end conference by P. N. Baker, Section notes, readers' letters and book reviews, complete the issue.

BATTERY SYMPOSIUM

THE Inter-Departmental Committee on Batteries are sponsoring a symposium from the 18th to 20th October 1960.

It will be held at The Pavilion, Bournemouth, and it is expected that about 25 papers will be presented, covering a wide field of subjects concerned with research, development and application of battery systems. Further information may be obtained from Mr. F. C. Wells, Ministry of Aviation, S.R.D.E., Christchurch, Hampshire.

ESSAY COMPETITION

THE publishers of *Research* invite entries for their 1960 Waverley Gold Medal essay competition. The Medal and £100 will be awarded for the best essay of about 3000 words describing a new scientific project or practical development, giving an outline of the scientific background, the experimental results and the potential application of the project or process in industry. The competition is designed to encourage the scientist in the laboratory or the engineer in the production plant to express his views and translate his work into an essay which would be readily understood by other scientists, directors of industrial firms and others interested in science or technology. A second prize of £50 will be awarded and also a special prize of £50 for the best entry from a competitor under the age of 30.

A new 'Application in industry' essay competition is being introduced this year. Its purpose is to interest candidates, who must be practising scientists under the age of 30, in the practical problems encountered when applying scientific developments to industrial projects. Essays of some 5000 words are invited, in which any new idea, concept or experimental result put forward in the recognized scientific literature in the last two years is discussed from the point of view of its commercial exploitation in the next decade.

For both competitions, joint entries by not more than two candidates may be submitted and the last date for the receipt of entries is the 31st July 1960. Further details will be supplied on application to *Research*, 4–5 Bell Yard, London W.C.2.

SYMPOSIUM ON DATA TRANSMISSION

THE Benelux Section of The Institute of Radio Engineers will hold an international symposium on data transmission at Delft, Netherlands, on the 19th and 20th September 1960. The symposium, which will be conducted in English, will be concerned with the problems of transmitting and receiving information in digital form.

Further information is available from the Benelux Section, The Institute of Radio Engineers, Postbus 174, The Hague, Netherlands.

MAGNETISM AND MAGNETIC MATERIALS

A CONFERENCE on magnetism and magnetic materials will be held in New York from the 14th to 17th November 1960 at the New Yorker Hotel.

This conference (the sixth annual) is sponsored jointly by the American Institute of Electrical Engineers and the American Institute of Physics, in co-operation with the U.S. Office of Naval Research, the Institute of Radio Engineers and the Metallurgical Society of the American Institute of Mining and Metallurgical Engineers.

Further details can be obtained from the Local Chairman, Mr. L. R. Bickford, Jun., I.B.M. Research Center, Yorktown Heights, New York, N.Y., U.S.A.

Contents of the current *Proceedings*

The date in italics is that of the Journal review, special article, or synopsis. Where given, the date in capitals is the month in which a paper or monograph was published individually

PART A. POWER ENGINEERING (JUNE 1960)

E. C. ROGERS, M.SC., *and* D. J. SKIPPER, B.SC.(ENG.). PAPER 3144S, JANUARY 1960 **Gaseous-discharge phenomena in high-voltage d.c. cable dielectrics** *March 1960*

D. B. CORBYN, B.SC.(ENG.), *and* N. L. POTTER, B.SC.(ENG.). PAPER 3135U, NOVEMBER 1959 **Characteristics and protection of semiconductor rectifiers** *February 1960*

I. F. DAVIES, B.SC., *and* D. DUNTHORNE, B.SC.(ENG.). PAPER 3192U, JANUARY 1960 **Application of power transistors to the operation of gas-discharge lamps from d.c. supplies** *April 1960*

E. R. LAITHWAITE, M.SC., PH.D., D. TIPPING, B.SC., *and* D. E. HESMONDHALGH, M.SC. PAPER 3225U **Application of linear induction motors to conveyors** *June 1960*

R. L. GRIMSDALE, M.SC., PH.D., *and* P. H. SINCLARE, M.SC. PAPER 3131S, DECEMBER 1959 **Design of housing-estate distribution systems using a digital computer** *April 1960*

U. G. W. KNIGHT, B.SC.(ENG.). PAPER 3138S, DECEMBER 1959 **Logical design of electrical networks using linear-programming methods** *April 1960*

Discussion on **Method of measuring self-inductances applicable to large electrical machines** before a Joint Meeting of the Measurement and Control, Supply and Utilization Sections

Communicated discussion on **Electrical materials and components for aircraft power equipment operating at high temperatures**

Communicated discussion on **Supply-voltage and current variations produced by a 60-ton 3-phase electric arc furnace**

Communicated discussion on **Selection of relaying quantities for differential feeder protection**

PART B. ELECTRONIC AND COMMUNICATION ENGINEERING (MAY 1960)

See the Journal for May 1960, p. 317

PART C. MONOGRAPHS (MARCH 1960)

See the Journal for March 1960, p. 183

OVERSEA ATTENDANCE REGISTER

DURING the period 20th April to 14th May 1960 these members called at the Institution building and signed the Attendance Register of Oversea Members:

ADAMS, N. G. (Mill Valley, California)
ALLAN, W. J. W. (Dunedin, New Zealand)
BEZJIAN, M. Z. (Baghdad)
BONN, C. D. M. (Baghdad)
CHASE, B. C. (Adelaide, S. Australia)
D'CRUZ, J. (Nairobi)
DUNSTAN, N. E. (Hong Kong)
HARRIS, A. (Redwood City, California)
PERRY, A. M. (Kingston, Jamaica)
SCHUNKER, C. V. (Bombay)
SMALL, A. J. D. (Nairobi)
TAN, T. O. (Penang, Malaya)
TRAFFORD, W. (Kuala Lumpur, Malaya

BULLETIN OF THE SECTIONS

MEASUREMENT AND CONTROL

Low-drift transistor d.c. amplifiers

A PAPER entitled 'Low-drift transistor chopper-type d.c. amplifier with high gain and large dynamic range', by I. C. Hutcheon and D. Summers, was presented by the authors at Savoy Place on the 15th March 1960, with the Section Chairman, Prof. A. Tustin, in the chair. An article based on the paper appears on p. 362.

A great deal of effort has been expended in the past in surmounting the problems of drift in d.c. amplifiers and, with the introduction of transistors, this problem has reappeared. It is not surprising, therefore, that the paper aroused considerable interest and provoked a lively discussion.

Mr. Hutcheon introduced the paper in a rather unusual manner by examining the other possible means of solving this problem. This procedure has the advantage that the background of the work is filled in and discussion facilitated.

He confined his remarks to d.c. amplifiers which convert the d.c. signal to an a.c. signal by means of a modulator or chopper. He described the essential design features of vibrating capacitor and contact modulators in some detail, and then reviewed briefly other devices such as second-harmonic, Hall-effect, and balanced-diode modulators. He pointed out that one of the prime causes of drift in the amplifier described in the paper was the chopper transients.

His remarks were concluded with an impressive demonstration of its insensitivity to stray field effects. The amplifier was arranged to indicate an input of 1 mV d.c., and the 230 volt a.c. mains were then connected between each side of the input in turn and earth; there was no change in the indication.

Silicon for chopping

Dr. G. B. B. Chaplin opened the discussion. He pointed out that, at the moment, the best results appeared to have been achieved with the photoconductive chopper which gave voltage and current drifts of less than $1\mu V$ and 10^{-13} amp respectively. Then, in considering the authors' circuits, he expressed some doubt as to the advisability of controlling the temperature of the input chopping transistor, and extolled the advantages of the silicon transistor for this function.

It appears, however, that a low chopping frequency is essential with silicon transistors because of the importance of transients. Dr. Chaplin gave particulars of a method of suppressing these transients by subsequent chopping in the amplifier at double frequency.

Mr. D. P. P. Nambiar mentioned a technique for drift compensation using a silicon resistor, or Sensistor, and Mr. E. H. Cooke-Yarborough gave some details of a d.c. amplifier he is developing using transistors pulsed at a high frequency. Mr. Cooke-Yarborough's remarks were amplified later in the discussion by Mr. P. M. Thompson, who claimed to have operated transistors with input currents of 10^{-11} amp employing this pulsed method.

Other speakers asked questions on the possibilities of improving the performance of the amplifier still further by more precise control of the temperature of the chopping transistor. It was tentatively suggested that, in view of the small size of the transistor, it could be held below ambient temperature by the use of Peltier-effect cooling.

Mr. R. B. Stephen stressed the need for a similar amplifier with a bandwidth of 20 kc/s, and thought that the authors' amplifier could be used as the drift corrector in the familiar technique of drift correction in wideband amplifiers.

In replying to the discussion, Mr. Hutcheon stated that he was now using silicon transistors for chopping, and emphasized that the amplifier was designed for industrial use and therefore had to be virtually foolproof. This was a prime consideration in the design.

A vote of thanks to the authors, proposed by Prof. Tustin, concluded the meeting.

One cannot help commenting on the rapid progress in this field. Four or five years ago, the problems of using transistors in high-performance d.c. amplifiers seemed almost insuperable, and now most of these difficulties have been effectively solved.

F. C. W.

Machines which learn by experience

BY tradition, the last meeting of the session is a lecture on a subject of general interest; by a break with tradition, the Section arranged this year for the lecture to be followed by a discussion. So it was that on the 3rd May 1960 at Savoy Place, Mr. C. E. G. Bailey introduced the subject of 'Teaching and learning machines.'

The first stage in the argument was a teaching machine which adapted itself to the progress made by its pupil, and one such machine, teaching the preparation of punched cards for computers, was demonstrated. The action of this machine is governed by the signals fed into it by its pupil; and from this it is not too long a step to a machine which is designed to use its experience of various input signals to adapt itself to some purpose or other. Thus the problem of a machine which learns is, in principle, solved.

To convert the 'paper' machine into a real one is a more difficult task. Many designs would be uneconomic: for example, a computer mounted on roller skates would be an expensive equivalent for a bicycle.

Mr. Bailey showed how the number of components might become alarmingly large if enough were provided initially for all possible states of the machine when the learning process was complete—e.g. if all possible connections were provided by means of fuses and the unwanted ones blown during learning. Somehow the number 10^{124} appeared at this stage. The way out of this problem is to let the machine make its own components—for example by growing metallic dendrites in a solution. This has the advantage that the learning

process is reversible and can adapt itself to slowly changing conditions.

In the discussion of machines like these, it is tempting to use misleading metaphors of an anthropomorphic kind, and Mr. Bailey clearly stated the limits permissible for such usage and the importance of being able to translate it into strict physics if challenged.

Machines which imitate their teachers

In the discussion, Dr. A. M. Uttley distinguished between learning that so-and-so was a fact and learning a particular skill. Machines can learn in either sense; one requires a digital device, the other an analogue. The learning of a skill requires that a goal shall be prescribed, either by the environment or by a teacher; a teacher may either tell the machine that its actions are 'right' or 'wrong' or require it to imitate him. Machines which are left to learn in a changing situation may be said to show a phase lag like that of a servo system; this suggests the possibility of compensating for the lag.

Most of the subsequent speakers described particular devices of their own. Mr. P. Huggins had a machine which recognized defects in metal tubes and which was intended to learn from the decisions of an inspector on the shop floor whether any defects in a particular case were to be regarded seriously or not. Dr. R. L. Grimsdale had found that his computer developed undesirably rigid ideas on how to deal with a situation. Dr. F. H. Sumner's computer learned how to look for information in its own two-level store more efficiently than the programmer could do it himself.

The discussion continued long and vigorous; and even after the Chairman, Prof. A. Tustin, had closed it and thanked Mr. Bailey for his fascinating lecture, there were still two machines being demonstrated—one already referred to, and another, studded with coloured lamps, which baffled those who gathered round it, but which was believed to be learning something.

This was indeed an interesting meeting, but it might have been still better if there had been more impromptu discussion of Mr. Bailey's introduction and fewer miniature lectures prepared beforehand. One suspects that Mr. Bailey, if stimulated by an appropriate sequence of input signals, might have reacted in a manner both educative and entertaining. A. C. L.

SUPPLY

Motes and monitors

THE meeting of the Section at Savoy Place on the 16th March 1960 was an excellent example of the way in which a paper, at first sight of special and perhaps rather limited interest, can provoke a wide-ranging and most interesting discussion. Proof was forthcoming when, with Dr. J. R. Mortlock in the Chair, Dr. D. H. Grindell presented his paper 'An electrostatic dust monitor' (reviewed on p. 364).

Dust, with noise, stinks, and ugliness, is one of the major plagues of our industrial way of life—it has increased, is increasing and ought to be diminished. Any one of our members who contributes to this end deserves well of us and of the general public.

Dr. Grindell's dust monitor is an ingenious device that is designed to count the dust particles in any flow of gas, and thus give an indication of the amount of dirt emerging from a chimney or the like. The particles in a sample stream of the gas are first electrified and then attracted to an electrode. The resulting minute current in the electrode is amplified and used to feed a recorder.

The underlying theory, set out in the paper, provides more a scientific background for the device than a basis for its design, as the author himself with disarming candour admitted when he said that the theory had been included mainly on aesthetic rather than on practical grounds.

Smoking in the Theatre

Opening the discussion, Dr. J. S. Forrest said that his own organization poured into the atmosphere no less than five million tons of dust a year. In extenuation, he hastened to add that he was busy designing a dust monitor of his own and said that he was concerned, together with Mr. W. L. Snowsill, to try to measure directly the dirtying power of this effusion when it falls on our windows and washing. He had something to say about the unreliability and illogicality of visual methods of estimating the foulness of chimney-stacks—one hopes that H.M. Alkali Inspectors will pay due attention.

Other speakers had doubts about the accuracy of the author's calibration of his instrument but were brought down to earth by Mr. W. A. Clement, who felt very strongly that Dr. Grindell's half-loaf was much better than no bread. He gave an interesting account of his own efforts to correlate the appearance of the charts inscribed by the monitor with the behaviour of his boilers, efforts aided by a week's round-the-clock marathon of boiler-watching.

Dr. Grindell had embellished the presentation of his paper by a practical demonstration of his apparatus and incidentally did what few have done—he smoked in the Lecture Theatre without being rebuked by the Chairman. C. J. O. G.

Annual Dinner-Dance

WITH the bare recording of an event which ranks high in the social activities of the Section, it is not possible to clothe it with the warmth of congeniality which is highly evident on such occasions. On the 30th March 1960, both the dinner and the dance were enjoyed by over 400 members and ladies.

Dr. J. R. Mortlock, Chairman, in welcoming the President, Sir Willis Jackson, Lady Jackson, representatives of the other specialized Sections, and the assembled company, indicated that short speeches were the order of the evening, lengthy ones being reserved for events at Savoy Place. The President, in making the response, expressed his appreciation most sincerely, with wit and commendable brevity

The evening appeared to pass all too rapidly, which speaks well for the success of the function. F. C. W.

At the Supply Section Dinner-Dance at the Connaught Rooms, London, on the 30th March 1960

From the left are: Mr. R. A. Marryat, Mr. J. D. Peattie, Mrs. J. R. Mortlock, Sir Willis Jackson, Dr. J. R. Mortlock, Lady Jackson and Prof. A. Tustin

Water-turbine-driven induction generators

IN opening the meeting at Savoy Place on the 13th April 1960, the Chairman, Dr. J. R. Mortlock, said that he had been asked by Dr. A. L. Williams to present his unreserved apologies to Dr. B. Salvage to whom he had attributed, through an incorrect reading of past proceedings in the Theatre, a complete reversal of the opinion expressed on the former occasion. The Chairman added that, as Dr. Williams was gravely concerned at having so incorrectly dealt with the views of a fellow-member, he had undertaken, with the approval of Dr. Salvage, to make this statement.

The meeting then proceeded with the presentation and discussion of the paper covered by the report below.

THE North of Scotland Hydro-Electric Board runs a lot of smallish water-turbine-driven induction generators, and their characteristics and peculiarities were clearly described by Mr. C. L. C. Allan in his paper on the 13th April. An article based on the paper will be found on p. 359.

Engineers like to get something for nothing, said Mr. P. Richardson in the discussion. He was referring to the line capacitance MVAr available (for free?) to magnetize induction machines, and suggested that this might be useful if an amenity-minded public started to insist on transmission circuits being cabled.

A beautiful simplicity

The long-haired contributors (Prof. Say's phrase) did not appear to agree on the interpretation of Mr. Allan's switching-in oscillograms, while the hairy-chested majority were exercised about economics. The induction generator needs no field equipment, governing, or built-in flywheel effect—all handsome savings. Mr. T. W. Wilcox granted the machine a beautiful simplicity, though it did raise problems not quite so beautiful: overvoltage was one, resulting from the possibility of self-excitation on line capacitance. The low speed of some of the sets was noted, but Mr. H. E. Clapham recounted a tale of a geared set switched in at subsynchronous speed to the accompaniment of a noise like the shunting of railway trucks.

The paper was unusually interesting and the discussion matched it. Replying, Mr. Allan made a remark likely to be a runner in the competition for the understatement of the year: 'When you blow up people's radio sets on overvoltage, they are quick to point it out.' M. G. S.

ELECTRONICS AND COMMUNICATIONS

A challenging medium

RADIO propagation is a subject which does not usually attract a large audience, but from the attendance at the meeting at Savoy Place on the 23rd March 1960 it was evident that Mr. G. Millington's lecture on 'The challenge of the propagation medium to the radio engineer' was expected to be of unusual interest. The Chairman, Mr. M. J. L. Pulling, considered this to be a great tribute to the lecturer.

Beginning with Maxwell and Hertz, Mr. Millington traced the development of the radio art and showed how at each stage the propagation medium had presented the engineer with opportunities to exploit and obstacles to overcome. In this advance the ionosphere had played a major part, and perhaps it was just as well, for if we had to rely solely on ground waves for world-wide communication we should have to radiate a power of 10^{700} kW from a transmitter at the North Pole in order to obtain a field strength of 1 μV/m at the Equator. The ionosphere was, however, a mixed blessing, and many ingenious developments in aerial and reception systems had been necessary to combat its vagaries.

As the art had progressed and higher bands of the frequency spectrum had been exploited, the troposphere with its anomalies had begun to make its presence felt and hills had presented obstacles which could no longer be ignored. The medium had also confronted the engineer with such problems as atmospheric noise, polarization errors in direction-finding, and multipath effects in communication. He had overcome many of these hindrances, but one wondered what new obstacles and possibilities it had for him in the space age.

Mysterious ether

Mr. J. A. Smale, who opened the discussion, suggested that it would have been better for the engineer who had to maintain a communication service if the ionosphere had never been discovered, for then a comprehensive cable system would have been developed much earlier. Capt. P. P. Eckersley also extolled the virtues of communication by cable, but Dr. R. L. Smith-Rose asked why it was that the cable engineers had not made more rapid progress—after all they had had 50 years' start on radio. The latter also commended to us the study of

the historical background and recalled the mysterious ether of the 1920's which no one had succeeded in defining.

Dr. R. C. G. Williams spoke of the inefficient use of ground stations for broadcasting and looked forward to the possibilities of using satellites to obtain greater cover. The special propagation problems which are encountered in the use of radio for navigational aids was raised by Mr. Caradoc Williams. Here we were interested in the phase velocity of the waves and the effects which the ground had on it. Other contributors spoke of the ways in which multipath distortion might be overcome and reminded us of the equally important problems imposed by the limits of the radio spectrum.

In thanking Mr. Millington for his stimulating lecture, the Chairman remarked on the wide field which had been covered during the evening. B. G. P.

Sociable scientists or good-time Charlies?

In the Netherlands in 1957 we were made to feel we were the guests of the country and, were it not for the fact that so much was attempted in light current and light entertainment, the Section visit might have added to its qualities of contrast, hospitality and friendliness, that of relaxation; but the Dutch people had not been given enough time in which to show us everything, and we left the Netherlands amazed, sated, grateful and delighted at an opportunity taken.

The Radio Section, as it then was, had broadened its vista, the engineer knew no frontier, and the parent was sampling the pleasures and experiences so often prescribed for posterity.

This essay in Continental visits was a first step from which there could be no turning back; but, since it was felt that many electronics engineers would regard this Section activity as one which they could not readily or conveniently join, an endeavour had to be made to alternate visits to the Continent with visits in this country, although this aim was not immediately realizable.

In Paris the following year the mixture was varied somewhat; the ladies were allowed (perhaps unwisely) ample time to indulge their passion for ribandry, that feminine penchant for sampling, testing, and pricing merchandise, for information only! On the other hand, the men satisfied their thirst for knowledge by sipping gently and not infrequently in well known laboratories and communication establishments, the better to enjoy the amenities of the city of fashions and good taste in their leisure hours.

One morning, in the small hours, three of us broke away from the party which had been deposited at the hotel by the coach driver, to find an all-night bistro where we could satisfy our lust for the plain, simple things of life—bacon and eggs! We had had a full day. We had taken our science lightly and our sociability seriously. We had no thought for the spectacular show at the Lido, which had been a fitting climax to the evening's entertainment, nor did we reflect that one of us had been decapitated by guillotine that very evening at the hands of a stage magician in full view of the audience; our thoughts turned to home and gifts for the family, and as we walked back to the hotel through the cool, swilled streets of Paris, two of us at least cherished memories of similar escapades we had had in London many years before.

Whither next? Perhaps Birmingham or Cologne, or maybe both—they must all be visited. Professionally, we cannot ignore what goes on around us. Every county, every country has something to say from which we can learn much, and in varying our experiences we learn a little of others' ways of life and through them perhaps a little more about ourselves. Social activity may well fill in the gaps for those lacking the technical fervour to be nourished entirely on science—or it may be the *raison d'être*. T. B. D. T.

[Mr. T. B. D. Terroni is Chairman of the Section's Social Sub-Committee.]

Triple bill

For many years now it has been the practice of the Section to allocate specially one meeting each session for the presentation and discussion of papers provided by the younger members. The origin of this arrangement, it must be confessed, was a certain occasion when the Committee in preparing its programme of meetings found itself with no paper available for a particular date and this suggestion was made and adopted solely as an expedient for filling the gap. The innovation proved so successful, however, that it was repeated the following session and, in fact, every year since.

It is now an established custom, and on the 7th April 1960 at Savoy Place it took the form of a joint meeting of the Section with the London Graduate and Student Section at which three papers were given, each of these in turn being read, discussed and replied to by its author or authors.

The first was entitled 'Novel methods of speed control applied to a standard 3-phase squirrel-cage induction motor', by G. K. Creighton and W. M. Somerville, and particularly

UTILIZATION

dealt with the ways of achieving speed stabilization. An article based on this paper was published in the December 1959 *Journal*, p. 721.

This was followed by a paper by R. M. Epps, who took as his subject 'Pre-set screwdown control in steel rolling mills'. He gave details of such controls and error amplifiers and of the beneficial results as regards the dimensions of the rolled product which have been obtained where this system has been installed.

In the third paper, 'Linear electrical machines', the author, P. J. Lawrenson, covered the construction and application of these unconventional engines, including the use of one 1400ft long as an aircraft-launcher during the Second World War.

All the papers were of quite a high order of merit, and, as the Chairman, Mr. T. E. Houghton, observed in proposing a well deserved vote of thanks to the various authors, this augured well for the calibre of the future senior members of the Section. R. H. R.

News from the Centres

NORTH STAFFORDSHIRE SUB-CENTRE

Insulation levels

After formally welcoming three new Corporate members at the meeting at Stafford on the 18th January 1960, the Chairman, Mr. A. Asbury, introduced Mr. G. B. Harper and invited him to read his paper on 'The selection of insulation levels and tests for high-voltage transformers'. (A short article based on this paper appeared in the June 1959 *Journal*, p. 380.)

Mr. Harper reviewed the factors which influence the selection of transformer insulation levels on the 132kV and 275kV Grid systems and suggested that significant capital savings might be made on transformers for voltages higher then 132kV by adopting lower levels than those now specified, provided that extensive service experience with suitable surge diverters proved their reliability.

A vigorous discussion was opened by Mr. H. E. Pettitt and continued by a large number of members who reviewed the subject from all angles. In proposing a vote of thanks to the author, Mr. C. C. Pimble said he represented one of the best customers of the Central Electricity Generating Board, and as a customer he liked 'to get a bit off'. On the other hand, he would deprecate this at the expense of reduced reliability, and welcomed the cautious approach indicated in the paper. He thanked the author for his able presentation of the paper, which had attracted a high level of discussion. It was of real interest to engineers on both the manufacturing and the supply sides.

Before closing the meeting the Chairman called the attention of members to the reports of Council meetings which were being published in the *Journal*. He invited comments on these and any suggestions for possible improvements in their presentation.

Home electrical wiring

At the meeting at Stoke on Trent on the 12th February, two companion papers on the provision of adequate electrical installations were read, the one, by Mr. C. A. Belcher, dealing with installations in multi-storey flats and maisonettes and the other, by Mr. C. C. Hyams, in houses. The papers were discussed together.

Mr. J. L. Hood, opening the discussion, referred to the authors' suggestions of nine socket-outlets as a minimum for a four-room dwelling while recommending at least 14. Many public authorities still specified five outlets per dwelling, and if the cost of housing had to be reduced the electrical installation was the first item to be cut. He considered this to be a very short-sighted policy.

The discussion, which had to be curtailed because of insufficient time, was concluded by the Chairman, who gave many do-it-yourself practical tips on installation work. He sketched on the blackboard a simple method he had devised to form a cavity behind the skirting-board to take the ring circuit and provide facilities for later extension. He asked the authors if they could do anything with it, and a voice from the audience said 'They could patent it'.

Mr. K. A. MacKenzie proposed the vote of thanks and complimented the authors on the clear and interesting way in which they had presented the subject. He thought that all now had a better idea of the time and thought given to the design of installations and, as a ratepayer, he appreciated the care taken to get the best value for the public money spent.

Annual Dinner

The Annual Dinner held at Stone on the 19th February was attended by about 120 members and guests and again proved to be a most enjoyable occasion. Before dinner was served the Chairman, Mr. Asbury, briefly welcomed all our guests and hoped they would have an enjoyable evening. He did this, he said, because he felt it was quite wrong to delay our welcome until the formal occasion nearly at the end of the proceedings. Following the loyal toast, the Chairman also proposed a toast to 'the new Prince' born that afternoon, both toasts being received with obvious feeling and enthusiasm.

The toast of The Institution was proposed by Mr. Richard F. Summers, President of the British Iron and Steel Federation and Chairman of John Summers and Sons Ltd., who, after relating some of his more amusing personal experiences with electricity, referred to four generations of his family being closely associated with the steel industry.

Annual Dinner at Stone

From left to right: (seated) Mr. G. E. Griffiths, Mr. R. F. Summers, Mr. A. Asbury, Sir Willis Jackson, Mr. G. H. Gillam; (standing) Mr. R. W. Palmer, Mr. E. E. Gill, Mr. E. H. Cox, Mr. T. A. P. Colledge, Mr. S. Towill, Mr. W. K. Brasher, Mr. G. F. Peirson

He then spoke of the close relationship between the steel and electrical industries. The large amount of waste heat produced by a steelworks could best be utilized in generating electricity, while at the same time the works would take a large proportion of its requirements from the Grid. The installation of motor drives, electronically controlled, had contributed largely to the increase in steel output from 11 to 25 million

tons since the war. With a rising standard of living, the products of both industries would continue to increase.

Co-operation in research

The President, Sir Willis Jackson, replying to the toast, commented on the wide range of activities found in the area covered by the Sub-Centre. After referring to the large contribution made to the export market, he mentioned the training facilities represented by the University College of North Staffordshire at Keele and the local technical colleges. He then asked whether we were using trained engineers to the best advantage and suggested that much more could be done to break down their work into components, many of which could be performed by less-highly-trained personnel. He also appealed for more co-operation in research, as this was already being achieved with advantage in competitor countries.

The toast of 'Our guests' was proposed by Mr. G. H. Gillam, Vice-Chairman, who said we were honoured by the presence of so many distinguished guests that he felt unable to mention all by name but we were very pleased they had been able to join us. He mentioned the heavy demands made on the time of many of them and expressed our pleasure that they had been able to come.

He ventured to hope that at least one of our principal guests was relatively unknown to most of us: that was Mr. G. E. Griffiths, Governor of the Open Prison at Eccleshall, who responded to the toast in a truly memorable speech, a nice blend throughout of humour and seriousness.

Because suspicion is an occupational disease of prison governors, he had wondered whether the invitation might be intended as some sort of insurance, but he concluded from the manner and moral tone of the invitation to dine and speak that this was not so. He wished to make it clear at the outset that four generations of the Griffiths family had not been in prison and also that he now felt like an arts degree wandering among electrons.

More seriously, he said he had been impressed, on perusing some of our *Journals*, by the accent on ethics, education and the search for truth, and he congratulated The Institution on its recognition of the importance of these things. He also quoted many abstruse phrases which he had selected at random and hoped that someone after dinner would explain them to him in simple language, but it is doubtful whether he found anyone to attempt this. L. G.

NORTH LINCOLNSHIRE DISTRICT MEETINGS

Electrical engineering education

For many years an area of some 900 square miles east of the Trent and south of the Humber was to The Institution a 'white' area—owing allegiance to no Centre of The Institution and receiving only occasional visitations in the form of 'missionary' expeditions which rarely penetrated further than ten miles into its boundaries. Some of the local members, to keep themselves in touch with the world of electrical engineering, made visits by train and ferry to the meetings in Hull, and on one of these visits the idea of holding separate district meetings for members in North Lincolnshire was born.

With the very able assistance of the then Sheffield Sub-Centre Chairman, Dr. O. I. Butler, and his Committee, a meeting was called at the Angel Hotel, Brigg, on the 9th June 1958. Any doubts as to the success of the venture were allayed when some 47 Institution members and 50 visitors arrived to see the Institution films 'The inquiring mind' and 'Nuclear energy in the service of man'. At this meeting a local Convener, Mr. H. Peace, was appointed, together with a small committee to assist him.

This encouraging start was maintained, and during the 1958–59 Session four meetings were arranged and the average attendance of members was 32. The percentage of active membership in the district for this period was 57%. The 1959–60 Session has been equally successful, the average attendance being 29, and the percentage of active membership 56%.

One interesting feature of the meetings has been the large number of visitors present at each meeting, especially when compared with the number of members present.

A meeting on the 21st March 1960 was extremely successful, with an audience of 82, when Prof. G. W. Carter, the North Midland Centre Chairman, gave an informal lecture on 'Education for electrical engineering, with particular reference to Institution Examination Regulations'. Prof. Carter outlined the development of electrical engineering education from the days when it was simply a mechanical engineering course with an electrical bias up to the present time. He stated his belief that degree and Dip.Tech. courses in electrical engineering must in future be based on physics and mathematics rather than on mechanical engineering, and pointed out that the same idea lay at the foundation of the Institution syllabus.

Divergence of opinion

The discussion, opened by Mr. M. P. Rathbone, was lively and notable for the divergence of opinion of the general body of contributors from the line taken by The Institution. A very pertinent contribution was made by one of the Student members, who gave his experiences in attempting to take Part III of the Institution Examination, which necessitated travelling twice each week to attend the nearest course in Leeds—a total of 292 miles.

In reply, Prof. Carter said that he had been stimulated by the discussion and would take steps to raise some of the points at the Electrical Engineering Advisory Committee of the Yorkshire Council for Further Education, of which he was a member.

The vote of thanks proposed by Mr. F. C. Jones was carried with acclamation and Prof. Carter suitably replied.

So ended the ninth meeting for members in North Lincolnshire. For some a 25-mile journey across the Lincolnshire Wolds back home to Grimsby, for others a brief sojourn before mine host's fire before departing for home, but for all an enjoyable and instructive evening in the company of fellow engineers which, after all, is not the least of the benefits of being a member of The Institution. A. B.

News from the Centres (continued)

SOUTHERN CENTRE

Annual Dinner and Dance

In April 1959 the Centre held a Dinner and Dance at the Bedford Hotel, Brighton, to cater for those members who found it difficult to attend the Centre's main Dinner and Dance at Southampton. It was so successful that a second was held on the 8th April this year, and 163 members and friends were present under the Chairmanship of Mr. W. D. Mallinson. This has encouraged the Committee to make a booking for next year—Friday, 7th April 1961 at the Old Ship Hotel; the venue has been altered because more people are being catered for.

At this year's event Mr. H. F. Carpenter was the principal guest. His speech proposing the toast of The Institution was full of wit and sincerity and was acknowledged by Mr. A. H. Mumford, a Vice-President.

That was the end of the speeches, but the dancing went on.

H. R.

Southern Centre Annual Dinner and Dance at Brighton on the 8th April 1960

Pictured in this group are (from left to right): Mr. Mumford, Mrs. Mallinson, Mr. Mallinson, Mrs. Mumford, and Mr. and Mrs. Carpenter

News from abroad

MIDDLE EAST JOINT GROUP

Annual General Meeting

The 8th Annual General Meeting of the Group was held in Tehran on the 14th and 15th April 1960. This was the first time the Group had met in Tehran, and members and guests from Iran, Kuwait and the Lebanon enjoyed a very successful event.

The meeting opened with a visit to the Karaj Hydro-Electric Project, approximately 70 km NW. of Tehran. This project is being constructed for the Government of Tehran by Morrison–Knudson. The primary function of the scheme will be to control irrigation and generate power at peak periods. Snow was falling during this visit, and members from parts where summer had already set in enjoyed the change. Morrison-Knudson entertained the visitors to lunch.

At the Annual General Meeting, the Chairman, Mr. C. G. Moore, M.SC., A.M.I.C.E., reported briefly on the activities of the Group during the 1959–60 Session. Then Mr. R. C. Howes, A.M.I.E.E., presented a paper on 'The electric power development in Tehran'. This dealt mainly with the new Alstom 50 MW thermal generating station and the new distribution system in Tehran, and promoted a lively discussion. After the meeting an excellent buffet supper was provided by the National Iranian Oil Co.

On the following day members and guests visited the Alstom power station and one of the major substations in the distribution system.

This meeting concluded an excellent session. D. W. P.

Middle East Joint Group meeting in Tehran

A group at the buffet supper following the Annual General Meeting on the 14th April 1960

TRINIDAD AND TOBAGO JOINT GROUP

Oilwell engineering

Our first meeting for March 1960, on the 18th, was at Pointe-à-Pierre Club, where the paper 'Some unique engineering problems in completing an oil-well' was read by Mr. D. P. J. Holbrook, B.SC.(ENG.), A.M.I.E.E., and Mr. D. G. Harpum, GRAD.I.MECH.E.

The paper gave an outline of the many logging devices now available for assisting the geologist or reservoir engineer in his search for oil. These devices included the electric, sonic, induction and radioactivity logs.

On the 25th March the Group were the guests of the Trinidad Branch of the Institute of Petroleum, when Mr. Robert Bentley read a paper 'Some aspects of refinery and new construction inspection'. This described various methods of inspection of materials and welding in particular. The advantages and disadvantages of the techniques were discussed with reference to the particular requirements of each job, and a very interesting array of equipment was on view.

D. P. J. H.

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